ETN NEWS

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ETN is a non-profit association bringing together the entire value chain of the gas turbine technology community in Europe. Through the co-operative efforts of our members, ETN facilitates gas turbine research and technology development, promoting environmentally friendly stationary gas turbine technology with reliable and low cost operation.

In this issue

Christer Björkqvist
Managing Director

A revolution of the European energy market could be around the corner, fuelled by the economic recession and global discoveries of unconventional gas.

The impact of the "silent revolution" of unconventional gas exploration which started in 2003 is now starting to be visible. In 2010 shale gas was widely referred to as a potential game-changer, however at that time, focus was only on exploration in the US.

Recently, when I visited China, it became clear to me that the so called "shale gas revolution" will be a global revolution with a wider impact on world energy markets and the future energy mix than most of us had originally anticipated. Even though there are some environmental concerns, there is no doubt that the technology that combines horizontal drilling with hydraulic fracturing is working, if you compare the price of gas in US (2$) with the price in Japan or China (18$).

Already, by 2015 China expects to extract 6.5 billion cubic meters of shale gas and 10 times more by 2020. On top of that, major reserves of shale gas have been found in Argentina and in Poland. Poland is very keen to break its reliance on Russian energy and plans to extract an estimated 5.3 trillion cubic meters of recoverable reserves of gas with the help of major US oil & gas companies.

At the same time, more and more countries in Europe are realising that they cannot afford to subsidise renewable energy at the same level as in the past years due to the economic crisis. Fatih Birol, chief economist for the IEA recently stated that "Renewable energy may be the victim of cheap gas prices if governments do not stick to their renewable support schemes". The decision related to renewable support in the UK, where they recently have removed the tax incentives for solar panels, has been referred to as "a nail in the coffin of the solar panel industry". In Spain a similar decision to cut support schemes has been made, and more European countries are likely to be forced to follow this trend.

This highlights the importance of further research and development (RTD) of gas turbine technology and CCS in order to reduce emissions in line with the EU roadmap 2050. I am therefore very pleased to announce that our lobbying effort to include flexible and efficient fossil fuel power generation in the draft text of the EU's Horizon 2020 RTD Programme (2014-2020) has been accepted and will shortly be voted on in the European Parliament. The next challenge and important step will be to identify key R&D topics and more specific project proposals where the gas turbine industry are prepared to participate and contribute with the required co-funding. During 2012, we will, within ETN, work on this with the objective to submit suggestions to the European Commission in the beginning of 2013.

THE FUTURE OF GAS TURBINE TECHNOLOGY

We are pleased to announce that registration has opened for the International Gas Turbine Conference 2012. To view the interesting programme and to register please *click here*.

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Technical Committee 5 Asset Management

Project update: Risk-Based Decision Making

by Pascal Decoussemaeker, TC 5 Chairman, Alstom

Technical Committee 5 (TC5) on Asset Management is one of five Committees in ETN, which each covers the most crucial areas of future gas turbine technology development. The Committes serve as forums where the ETN members meet to share experiences and discuss ideas and initiatives, which can later be developed into initiatives and projects.

TC5 Asset management focuses on maximising the benefit from capital-intensive physical assets, such as Gas Turbine based power plants. This does not necessarily mean optimum maintenance, but also brings in aspects such as operation strategy, production losses and market fluctuations. The challenge of this holistic approach is how to use the technical information on the condition of the equipment to make the optimised commercial decisions. This often means dealing with uncertainties, for example questions such as how to make a decision to continue operation or not, if the equipment is in bad condition? What is the value of an inspection? What is the cost of cycling a unit?

Decisions on such questions require risk based decision-making techniques, for example Risk Based Inspections (RBI) or Reliability Centred Maintenance (RCM).

In TC5 we have concluded that risk based decision making is one of the main challenges to enable asset management to function. Many such techniques are already used in other industries, but have not yet been fully implemented in the power industry. It was therefore agreed to make a study of the state-of-the-art of risk based decision-making techniques and the implementation challenges for the power industry. The University of Cranfield has identified a student to perform this study. The work is presently in an initial phase. Once the first versions of the investigation are available, they will be circulated and reviewed by the asset management team members for comments. If you wish to to support this project, please contact the *ETN Office*. ■

The ETN Project Board and the H_2-IGCC Project

Interview with P. Breuhaus, ETN Project Board Member, and H_2-IGCC Project Partner of the Year

Peter Breuhaus, of the International Research Institute of Stavanger (IRIS), is the overall coordinator of the four scientific sub-projects of the H_2-IGCC project (including combustion, materials, turbomachinery and system analysis), as well as a member of ETN's new Project Board. He has also recently received H_2-IGCC's 'Project Partner of the Year' award for 2011. Below, Peter Breuhaus gives his insight into possible future prospects of the H_2-IGCC project, as well as his comments on the recent restructuring of ETN and the potential impact this can have.

How do you believe the progress after 2.5 years into the 4 years H_2-IGCC Project has been?

I believe there has been very good progress so far. It has been challenging given that there are 24 partners from all over Europe, working to achieve a common goal. Naturally it took some time for all partners to move in the same direction. However, ETN as the project coordinator did a good job in forming one team. Moreover, in an R&D project, unexpected challenges inevitably appear from time to time, and R&D people are often very optimistic, meaning that keeping to the timeline has been challenging. Nevertheless, I believe we are on the right path and continuously moving forward, and I expect that we will reach our target by the end of the project.

Following the completion of the H_2-IGCC project what do you think the next steps could be? Do you envision a follow-up project or any potential spin-off projects?

A continuation of the project will of course depend on the initial results, particularly the results of the techno-economical analysis, which has just begun. However, it is already clear that some results could potentially be used in other areas, for example those concerning hydrogen-rich combustion. These results could be of interest when H_2 is used as a bulk energy storage system for renewable energies, where energy demand is low. Then H_2 combustion in Gas turbines may become an issue when the gap in electricity supply and demand needs to be closed at a different time. I mention this as it currently seems that the ongoing EU FP7 programme and the future Horizon 2020 programme may not include gas turbine specific calls for research project proposals. Other possibilities for transferring expertise and experience and utilising them in other contexts include material technology as well as fuel flexibility. These are also important issues, for example, when promoting biogas production and its usage in GTs. In this context, fuel flexibility could reduce demand for sophisticated gas treatment and processing of the biogas, thus reducing the complexity of the plant and investment in components thus resulting in improved availability.

You were recently nominated by the ETN Board to be a member of the newly established ETN Project Board. What added value do you believe the Project Board will bring to the ETN platform?

I believe the Project Board is a positive development, enabling ETN to further strengthen the potential of project initiatives, through added expertise, cooperation and organisation. Given that ETN represents all the stakeholders of power generation, R&D initiatives can be considered from a more holistic approach than would be the case in consortiums consisting of only one section of the value chain. This is, in my view, also one of the main differentiators and advantages of projects such as H_2-IGCC. And this is also reflected in the make-up of the Project Board. Therefore, I think that the Project Board can further support this approach, in collaboration with the ETN Board.

ETN membership, activities and initiatives have expanded over the past year, thus leading to the re-organisation of the ETN internal structure, including the new Project Board. As a Project Board Member, what do you believe the focus of ETN should be in the upcoming years, and what direction would you like to see ETN take?

As indicated in the question, there have been many developments in ETN recently, and I expect to see further developments in the future. I also foresee changes to the technical focus of ETN and to the direction of future projects. I base this on changes in the environment (namely climate change) which will see an increased focus on renewable energy sources and energy efficiency, resulting in the need to move from focusing "only" on the effectiveness of the gas turbine (further increase of TIT, reduction of leakages and cooling air needs) to a more systems-oriented approach,

Continued on page 4

The ETN Project Board and the H_2-IGCC Project

Continued from page 3

as can be seen in the framework of the H_2-IGCC project. So I would expect a move towards combining GTs with renewable energies (solar thermal and biogas for example) as well as perhaps in combination with energy storage. Focus on energy efficiency might make it necessary to move further in the direction of reducing waste heat and thus combine it with industrial processes where heat is needed, as well as with district heating. This would result in challenges related to plant dynamics and part load behavior of the engine in connection with other processes and systems. The other question which might arise, and which is related to the above, surrounds a change from large scale power plants towards smaller distributed units. Overall, I expect that there will be a wide range of areas where activities and R&D projects involving GTs will be necessary, despite the fact that EU R&D programs no longer have a clear focus on supporting further development of GTs only. This may not be directly visible and it will undoubtedly be a task for ETN and the Project Board to ensure awareness and make it clear that GTs are not an off-the-shelf technology, but one that requires continual technological development. However, I am confident that this can be done by ETN in its position as a living and learning organisation, which is well positioned to adjust to changing boundary conditions. ■

On the way to actual material properties

by: Yingzhi Li, Paul Stevens, Harrie Hulshof and Arthur Stam (DNV KEMA)

In determining Fitness For Service (FFS) or in finding the cause of a failure, it is necessary to know material properties. For example, fracture toughness which indicates the resistance to unstable crack growth, is very important in assessing structural integrity. The reality is however, that these parameters cannot be determined without destructive testing. Several attempts have been made to determine actual material properties with non-destructive testing. These methods are, however, deemed to be applied in the laboratory, and therefore unsuited to determine properties of large components such as turbine rotors. Therefore, DNV KEMA has developed a non-destructive system to determine material properties on site.

Failure Analysis (FA) and Fitness For Service (FFS) should be based on material property data of the component in its actual state of damage. However, actual parameters are not known, and therefore nominal material properties are used, determined according to norms. The big disadvantage of applying nominal parameters is that calculated residual life fractions may result in conservative estimates. This can mean that a component would be calculated to have a life smaller than a 4 years inspection period (unfit for service), where it would be over 8 years based on actual material properties. Another disadvantage is that specific degradation, such as embrittlement, can be overlooked. Destructive testing in a laboratory of e.g. a turbine rotor is not an option to overcome these disadvantages.

Figure 1: DNV KEMA's indentation test device measuring actual material properties.

DNV KEMA therefore developed a system for carrying out tests on site (see figure 1). The test is an indentation test in which it is possible to measure both the load and the

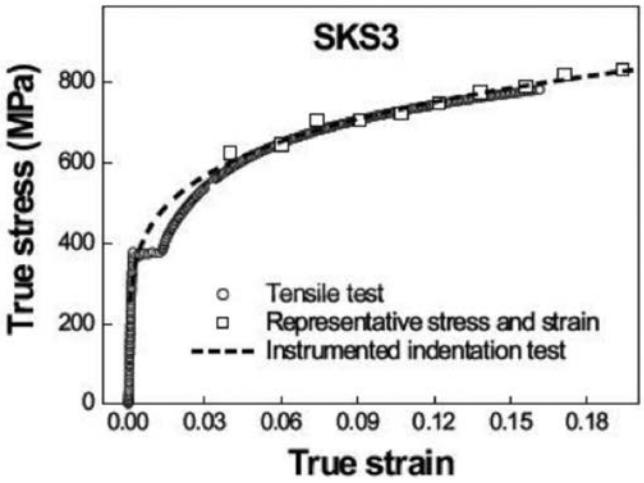


Figure 2: Uni-axial tensile curves, experimentally observed (dotted line) and predicted with indentation test procedure (straight line).

Continued on page 5

On the way to actual material properties

Continued from page 4

indentation displacement with high accuracy in the micrometer and nanometer range. Such a method is referred to as Instrumented Indentation Test (IIT). The initial unloading slope and the residual indentation depth after complete unloading are the important parameters. By using these parameters, the elastic and plastic properties of materials can be uniquely determined. For example, a low alloyed steel 10CrMo9.10 was investigated. Both the experimentally observed uni-axial tensile curve and the predicted curve based on the indentation test and the procedure are shown in figure 2.

Besides the hardness, other basic mechanical properties, such as Young's modulus, yield strength and tensile strength, can be deduced from the indentation load versus displacement curves for loading and unloading. A multiple cyclic loading-unloading procedure could be used (see figure 3) to measure the change of the Young's modulus, from which the fracture toughness can be derived. This is done by a dedicated procedure based on damage mechanics and finite element analysis, simulating the indentation test. Investigation is going on how to estimate creep damage on site. An off-line monitoring technique may be possible where the creep increment is determined by comparison of indentation tests results in time. Interpretation methods of the indentation technique are being developed, especially for estimation of fracture toughness and creep damage.

Many applications in gas and steam turbines are possible. For example, since parameters can be determined very locally, properties in and around heat affected zones and welds can

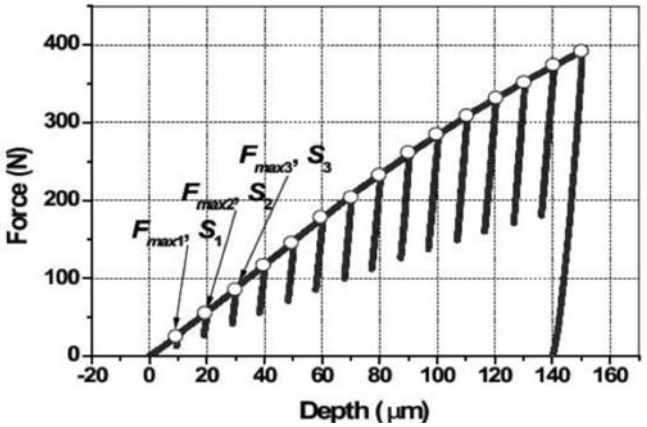


Figure 3: Multiple cyclic loading-unload procedure.

be determined. Another possible application is the testing of the quality of a thermal barrier coating.

In comparison with other miniature techniques, such as small punch, impression, micro-tensile or small ring tests, the IIT technique is fully non-destructive and can be performed on site, no sample machining is needed, and no sample processing is necessary. Other indentation measurement devices exist. However, most of them are for the measurement of nano-sized materials which require a restrict test environment, and are therefore impossible to be carried out on site.

Concluding, an indentation test has been developed to measure actual material properties, that can be used in fitness for service analysis or in failure analysis. Interpretation methods for fracture toughness and creep are under way which has yielded promising results.

For more information please contact the *ETN Office*.

Summary of the Turbine Forum 2012: Advanced Coatings for High Temperatures in Nice, France

An ETN representative attended the 2.5 day conference, which welcomed approximately 80 delegates from across the globe, representing both industry and academia. The primary focus of the conference was to discuss advances in coatings technology across the Gas Turbine industry, and the following topics were explored:

1. Complex MCrAlY Coatings and Bondcoats
2. Thermal Barrier Coatings (TBCs) including New Ceramics and Low Conductivity Systems
3. Diffusion Type Coatings (Aluminium, Chrome, Platinum-Aluminide)
4. Plasma Spray Technologies
5. Characterisation and Lifetime of Coatings

ETN members can obtain a full summary of the conference by contacting the *ETN Office*.

New ETN members

- Exxon Mobil (Germany)
- IRIS (Norway)

International Research Institute of Stavanger

- CNRS (France)

EU news summary

Horizon 2020: R&D in the new EU budget (2014-2020)

In July 2012, Cyprus will take over the Presidency of the Council of the EU. Most of the issues discussed at EU level in the next six months are predetermined by the progress made by the Danish Presidency (January-June 2012) and by the European Commission's work programme. However, the Cypriot Presidency has identified a number of focus areas.

The most significant area for ETN members is the start of the negotiations on the next EU budget (Multiannual Financial Framework 2014-2020). Cyprus aims to find the right balance between austerity and growth, including the allocation of 80 billion euro for R&D, which would also cover energy technology research and infrastructure projects.

Flexible and efficient fossil fuel power generation

ETN has been actively involved in the policy discussion on the priorities for the upcoming funding programme, the so-called Horizon 2020. ETN joined an initiative of the EU fossil fuel associations (EPPSA, Eurelectric, EUTurbines, Eurogas, Euracoal, GERG and Marcogaz) to publish a position paper on "The Importance of Flexible and Efficient Power Generation in Horizon 2020". The position paper has succesfully been submitted to European Union representatives and aims to feed into the final decision by EU law-makers, on the R&D priorities and funding levels. ETN is pleased to have received positive feedback on the suggested inclusion of flexible and efficient fossil fuels in the Horizon 2020 text, which is currently being discussed in the European Parliament, and being voted on shortly.

Energy Efficiency Directive: binding measures agreed

Following the final round of negotiations, the European Parliament, Commission and the Member States have reached a deal on the EU's new Energy Efficiency Directive (EED), a piece of legislation widely regarded as the most important tool in achieving the EU's self-imposed energy reduction targets.

Binding measures will be set across the 27-member states to enforce energy savings for the first time. The agreement will require governments and utilities to improve energy efficiency and lower the EU's consumption of fuel. However, the initial purpose of the EED, the introduction of binding targets to help the EU make 20% energy savings by 2020, has not been achieved. Instead, it is now expected that the EU will achieve roughly 15% savings in energy, excluding transport. Nevertheless, without the EED, the EU was expected to meet only about half of the initial 20% target.

Denmark, which has held the rotating EU presidency since January 2012, had made energy efficiency a priority, with backing from the Commission. According to the Danish Presidency, the introduction of the EED will save the European economy 44 billion euros in fuel expenditure and investments in energy generation and distribution. The European Commission has said the EED will increase the EU's GDP by 34 billion euros in 2020, and create 400,000 jobs. The many critics of the EED, however, have claimed that the legislation will have a significant negative impact on economic growth.

European Union Sustainable Energy Week 2012 (EUSEW)

SUSTAINABLE ENERGY WEEK 18-22 JUNE 2012

Director General for DG Energy, Phillip Lowe, pointed out that gas is one of the very few sources of electricity which does not require subsidies and declared that in the future gas should be used not just as a transitional fuel but as a long-term replacement for coal.

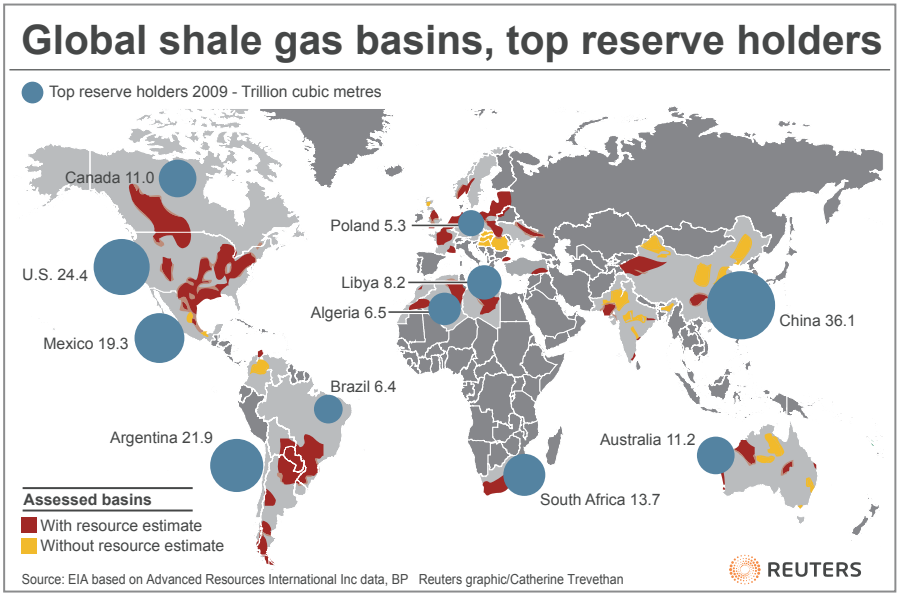
This year the 7th EUSEW took place on 18-22 June 2012, with a series of events and initiatives highlighting renewable energy and energy efficiency, including a high-level policy conference in Brussels with 4000 participants from more than 50 countries. Throughout the week, special events and activities across Brussels were held to attract attention to energy efficiency and sustainable energy themes.

For full details on the Conference and on Energy Days in Brussels, *click here*.

Chinese shale gas development presents opportunities

Christer Björkqvist, Managing Director of ETN, attended the NexTurbine 2012 Conference in Shanghai, China, as both a presenter and chairman. Among other discussions, there was a special focus on the increased exploration of shale gas in China, and the potential this holds for the future, as well as the repercusions this will have on the global gas market, and the demands for gas turbine technology.

The Chinese government is planning huge investment in order to exploit the country's vast reserves of shale gas. According to China's 'Resources Ministry,' the country has explorable shale-gas reserves of 25.1 trillion cubic metres. The government believes China can emulate the shale gas revolution currently under way in the US, where shale gas has already transformed the energy sector.



Five-year Shale Gas Development Plan

In March 2012, the Chinese government released its first five-year plan for the development of shale gas, setting ambitious production targets and emphasising the need for foreign co-operation and technology development. The plan set a target of reaching 6.5 billion cubic meters of shale gas production per year by 2015, a 6% increase on China's current natural-gas output. By 2015, according to the development plan, China is expected to have identified total exploitable gas reserves of 200 billion cubic meters and total proven reserves of 600 billion cubic meters. By 2020, annual production is forecast to reach between 60 billion and 100 billion cubic meters, due to intensive exploration in 19 designated exploration areas.

Also included in the plan is a proposal to carry out a two-year survey appraising China's shale gas reserves and exploring methods of increasing China's expertise on technologies and equipment required for the exploration and production of shale gas. The Chinese government is currently developing a policy framework for the regulation of the country's shale gas sector. Financial support policies and subsidies for shale gas, including price subsidies, preferential tax treatment and land subsidies will also be implemented.

Foreign Investment Encouraged

China's shale gas development plan states that competition within the shale gas sector will be promoted and indigenous companies will be encouraged to work in conjunction with foreign companies and research institutes with expertise in finding and exploiting unconventional natural-gas resources. The Chinese government has recognised the need for foreign co-operation to develop shale gas technologies, and companies including BP, Chevron and Royal Dutch Shell are currently involved in shale gas exploration joint ventures in China.

Decreased Dependence on Coal

In promoting the development of shale gas, China is aiming to move away from its current dependence on coal, which today generates around 70% of the country's electricity. Substituting coal for natural gas in power generation, will by 2015, reduce China's emissions of carbon dioxide by 14 million metric tons, sulphur dioxide by 115,000 tons and nitrogen oxides by 43,000 tons, it is estimated.

Difficulties in Exploiting Reserves

There are, however, some difficulties with exploiting China's shale gas reserves. The complex geology of shale reserves in China means developing shale gas is considerably more expensive than in the United States. Other factors including water shortages, insufficient natural gas pipeline infrastructure, government control over natural gas prices and environmental issues may also prove to be obstacles in the way of the achievement of the government's shale gas development plan.

Great Potential

Nevertheless, China is undoubtedly rich in shale gas resources which are suitable for scaled development and exploratory drilling for shale gas has increased

Continued on page 8

Chinese shale gas development presents opportunities

Continued from page 7

greatly in the past year. A report by the US Energy Information Administration in 2011 concluded that China's "technically recoverable" reserves were 50% greater than in the US, making China the largest repository of shale gas in the world.

Global Potential

Argentina is another country which has huge potential for shale gas development. Argentina's shale gas reserves are estimated at close to 22 trillion cubic metres.

Crucially, Argentinian reserves are also of high quality. In particular, the geology of the Neuquen Basin, which has the largest shale reserves in Argentina, is thought to be similar to that of several U.S. basins, enabling easy adaptation of current extraction techniques.

The Argentinian state energy company, YPF, is currently in talks with a number of international energy companies interested in joint ventures, and according to a June 2012 KPMG report on shale gas, the Argentine government is now actively promoting foreign investment in the sector.

Poland is believed to have the largest shale reserves in Europe. The Energy Information Administration has estimated that Poland could hold as much as 5.3 trillion cubic meters of natural gas, enough for the country to satisfy domestic demand for the next 300 years. To date, the Polish government has granted more than 100 shale exploration licenses to international energy companies.

Global Shale gas development could bring environmental as well as economic benefits. This has already been evidenced in the US, where replacement of coal by shale gas in power generation has resulted in a 7.7% reduction in carbon emissions since 2006, the largest reduction of any country.

The potential and impact of shale gas development in the European energy market, as well as worldwide, is a topic which will be discussed at the upcoming International Gas Turbine Conference 2012. ■

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