9th International Gas Turbine Conference

idgtE

the independent technical forum for power generation

The Role of the Gas Turbine in Today's Global Power Industry and other International Power Applications

21 November - Afternoon Workshop
22 & 23 November 2017 - Conference

Wyboston Lakes Executive Centre
Wyboston, Bedfordshire, MK44 3AL, UK

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ABOUT THE IDGTE CONFERENCE

Since the IDGTE International Gas Turbine conference was first introduced 18 years ago, IDGTE has successfully run this biennial event with top quality international speakers bringing the very latest developments in gas turbine technology and operations. The 2017 event is being held at the first class conference facility at Wyboston Lakes and is set to deliver an excellent technical programme, providing a great networking event. The theme for this year's conference is *"The Role of the Gas Turbine in Today's Global Power Industry and other International Power Applications".*

THE BACKGROUND

Over the last few years there has been a strong resurgence of interest in gas-fuelled plant in the UK – initially based on peaking gas engines, but with increasing recognition that flexible and efficient gas turbines are essential to replace the large amounts of coal and nuclear generation now facing imminent closure. Over the same period generation from coal fired generation has been reducing since the peak in 2012 and the major part of the shortfall in electricity supplies has been delivered by existing CCGT plants and the increase in output from renewables.

The increasing capacity contribution from renewable generation brings essential reductions in CO_2 emissions, however its inherent unpredictability also increases the requirement for flexible and clean generation that can deliver reliable balancing capacity for extended periods when needed. With heightened concerns about both global and local pollution, natural gas is the fuel of first choice for this role.

The conference will explore the resurgent and developing market for gas turbines and the latest technologies from around the globe. The opportunity will be provided to hear about the full range of gas turbine applications. Presenters will share their experience and provide the ideal forum for networking. If you or your company has an interest in gas turbine technology or combined cycle power generation, then this is the place to be this November. Register as a delegate and join with others in the industry for this unique and prestigious event.

CONFERENCE WORKSHOP

Tuesday 21 November

13:00 Registration

13.30 ***Conference Workshop***

There will be four workshop sessions, each with delegate participation. At our previous conferences we have found these sessions to be stimulating, with excellent interactive discussions bringing in a dynamic element as an important part of the conference. Presenting the material in open discussion style allows the presenters and delegates to check understanding, viewpoints and assess different operational needs and weigh different points of view in a less formal and extremely productive setting.

16.30 Close

19:00 Informal Dinner

CONFERENCE DAY 1

Wednesday 22 November

08:30 Exhibition open.

09:15 **Institution Welcome by the President and Day 1 Chairman**

09:30 Paper 1
Mike Benson, Development Director - Carlton Power

Keynote Address
The keynote address will be given by Mike Benson of Carlton Power who will set the scene for the conference ***"The role of the gas turbine in today's global power industry and other international power applications"***. He will reflect on how gas turbines have been a key component for mechanical and electrical power generation for over 50 years and explore how they may need to

operate in the future. Whilst the last decades have seen tremendous advances in the technical capabilities and application of these complex machines, major changes to the markets in which they operate and the advent of carbon emission constraints means that the role of gas turbines keeps evolving. He will explore the economic justification of new investments and the technology developments that will be important in the gas turbine opportunities of the future.

10:00 Paper 2
Marcus Scholz - GE Power

A Review of Energy Storage Systems and its Application with Gas Turbine Combined Cycles
The conversion and storage of mechanical, electrochemical and thermal energy has been explored for many applications to apply energy storage when it is abundant and recover it at a time of higher economic value. In the context of grid support with increased deployment of renewable sources like wind and solar power and resulting intermittency, energy storage represents part of the solution if the respective capacities can be made available short term.

Traditional storage technologies include pumped hydro storage and gas storage (both: cavernous and pipe-line systems), also heat storage technologies on a small-scale are well established solutions for hot water supply and medium size district heating systems.

More recently applied storage means are thermal storage in molten salts within concentrated solar power (CSP) plants for medium-scale and ongoing developments including compressed air energy storage (CAES), hydrogen-based energy storage and battery system as part of hybrid power generation.

Several development projects focus on optimising the adiabatic use of thermal energy storage systems and the challenge of reducing conversion losses, like that of solar thermal energy storage.

GE's experience ranges across most of these storage technologies and this discussion will compare the ESS technologies ranging from molten salt over compressed air and battery energy storage plants, and its optimum frame for applications.

10.50 Coffee/tea break

11:10 Exhibitor Session**:** Each exhibitor will give a short presentation to the conference.

12:00 Paper 3
Willibald Fischer – Siemens, Erlangen, Germany

Latest Developments in Siemens Large Gas Turbines
This paper will provide an update on the Siemens large gas turbine portfolio as the energy market has recently undergone a drastic change, especially when looking at combined cycle power generation. From base load/cycling operation the operational profile of many plants has changed to high cycling or daily start/stop operation. The reason for this change is the addition of renewable power. Given the expected volatile market environment the Siemens large gas turbine portfolio offers reliable and cost-effective solutions to our customers and is the best fit for combined cycle projects when considering the financial benefits and risks of projects in such markets – for both short term and long term view.

The paper will highlight, but not be limited to, successful projects using for example the SGT-8000H series, as Siemens most advanced frame with high operational and fuel flexibility and highest efficiency. This gas turbine series has not only set new standards for efficiency, but it also has become a benchmark in the industry in terms of reliable operation and robustness of design. With low life cycle costs, high reliability and availability, operational flexibility and low emissions it is a trendsetting solution for clean fossil power generation in combination with renewable power generation. With more than 80 units sold and 28 units with more than 310,000 hours in commercial operation and each unit handed over on time while meeting guarantees, the SGT-8000H series is widely accepted as a fully proven product series.

12:40 Lunch

14:00 Paper 4
Jan Schmitt - STEAG Energy Services GmbH

Advanced Performance Monitoring in Combined Cycle Power Plants
Rapidly changing boundary conditions in the landscape of the energy industry urge for a flexible operation of utilities. Amongst others, emission restrictions and increasing share of highly dynamic renewables demand combined cycle power plants worldwide to work outside their intended load range.

In order to cope with these challenges IT based solutions can be used as tools for optimisation of day to day operation as well as long term evaluation of equipment deviation. For a comprehensive approach, a mix of data based and model based calculations are to be used. These solutions help optimising the power plant as a complete system from gas turbine over HRSG to the water steam cycle. A vital part of these applications is the predictive maintenance. Advanced data models can help to support availability by reducing unexpected shutdown periods due to unforeseen events.

As all these tools are based on measured data the quality of results highly depends on the quality of input for the calculations. Therefore a proper and continuous evaluation of measured data is a requirement that cannot be neglected.

This work will present different kinds of IT solutions and show how they can benefit operators and owners for combined cycle plants. From many years of project execution a few practical examples will also be presented to give the audience an exclusive insight into experience and findings using the developed tools.

14:40 Paper 5
John MacDonald – RWE Generation UK

The RWE Developed System for Monitoring of Gas Turbine Fouling and Air Intake Filtration including Site Test Results

Compressor fouling occurs when there is unfavourable air quality and low efficiency inlet air filters. The impact on the gas turbine is reduced efficiency and output. Historically the GT OEM installed standard filters regardless of the local air quality and the operator tried alternatives through a trial and error process that took years. This was made difficult as suppliers claimed filter efficiencies that could not be verified. RWE, in partnership with Veotec, developed a portable system capable of sampling the air quality across each stage of filtration in-situ and measuring the number and size of particles in each sample. The equipment was installed at an RWE CCGT and air quality and filtration efficiency was determined. From these measurements and performance data, a revised filter configuration was developed, installed and tested at site. The project was completed in less than two years. This paper describes the issue, the new equipment and the site test results.

15:20 Coffee/tea break

15:40 Paper 6
Michael Welch - Siemens, Lincoln

Optimised Decentralised Power Plant to Support Intermittent Renewable Power Generation

Large scale deployment of intermittent renewable power generation is creating increasing technical and economic challenges for grid system operators, power generators and investors. Stable power system operation is under threat as inverter-connected wind turbines and photovoltaics do not provide rotational inertia to help stabilise grid frequency, with variable power generation creating large potential mismatches between supply and demand. Large, centralised fossil fuel plants originally designed for base load operation are now required to operate flexibly or as spinning reserve generation.

Quick-starting distributed power plant, located at strategically important locations in the distribution network, based on light industrial or aero-derivative gas turbine technology provides fast response and flexible operation, with power available on the bars within minutes even on a cold start. By employing multiple units to provide the necessary power plant output, high efficiencies can be achieved across a wide operating range with high ramp rates, multiple daily starts and load cycles possible with both low emissions and minimal impact on maintenance costs. Flexible combined cycle configurations, including water-free options, can be considered to further enhance efficiency.

Further improvements in response and flexibility can be achieved by integrating gas turbine technology with energy storage technologies. Lithium-ion battery systems, charged by low cost intermittent renewable energy, could be used to both black start the gas turbines and provide virtually instantaneous power. Carbon capture could also be used to generate additional revenue streams as well as matching the low carbon power produced by renewables.

16:20 Paper 7
Clive Moffatt - Consultant

Charting A Future for Gas Generation in Today's Energy Market

Electricity Market Reform (EMR 2010) created a myriad of conflicting incentives and penalties. A competition for subsidies has replaced the wholesale electricity market. Nothing gets built without

some form of Government intervention, however the current market for energy has driven up residential energy costs by over 50% since 2003 and industrial energy prices are the highest in Europe. Less intervention and more market based competition is required.

The Government (Amber Rudd 2015) has said that new baseload and peak gas generation is essential to keep the lights on by replacing coal (post 2025), the expected delays in the role out of any new nuclear and to support the growing volume of intermittent wind and solar.

According to Clive Moffatt nothing has happened to encourage new gas investment. On the contrary, the technology neutral Capacity Market (CM) has failed to deliver; DEFRA and Ofgem between them are poised to upset existing and new investment in essential flexible small scale generation and now uncertainty over EU negotiations on energy policy has further undermined investor confidence. His presentation will analyse the key economic and political drivers and inhibitors impacting on new investment in gas generation, examine how best the objectives of low carbon emissions and affordable security of supply could be realised, explore the flaws in the operation of Cfds and the CM and how greater reliance should be placed on market mechanisms to revive investor confidence and secure new investment and identify specific opportunities to secure what is best for the UK.

17:00 Expert panel and question session

17:45 Chairman's Summary

19:00 Conference Dinner

CONFERENCE DAY 2

Thursday 23 November

08:30 Exhibition Open

08:50 **Institution Welcome – Day 2 Chairman**

09:00 Paper 8
Akihito Kunihiro, Hiromi Ishii, Toshiyuki Hashi - Mitsubishi Hitachi Power Systems

Japan Gas Turbine Development Update and the Latest Experiences
Mitsubishi Hitachi Power Systems present an update of the latest large frame of F Class gas turbine and J Class gas turbine, and small frame of H Class gas turbine.

The latest 50Hz F Class gas turbine featuring a turbine inlet temperature (TIT) of 1,500°C in a 1 x 1 combined cycle configuration started commercial operation in 2015 with two additional units which started commercial operation in Thailand, bringing the fleet to four units in operation.

The first 50Hz J Class gas turbine featuring a TIT of 1,600°C started commercial operation in January 2016 and the second in June 2016. At 470MW, this is the largest gas turbine in operation in the world, design based on the successful experience of twenty-three 60Hz units in operation with over 360,000 hours.

Uprated J series gas turbine: JAC incorporates a new technology of enhanced air cooling combustor and started long term verification operation at MHPS validation power station (T-Point: Takasago-Point, which is operated on grid as IPP for a Japanese utility company).

A small class gas turbine "H-25" started commercial operation in 1988, and total accumulated operating hour is more than 6,600,000 hours. In this paper, 240MW Kinyereji Project (3 on 1 combined cycle x 2 units) will be presented as one of the projects which utilise H-25. This project is the first combined cycle project in Tanzania, which will be in commercial operation in 2018.

As mentioned above, MHPS's gas turbine technology development update and latest experiences will be described in this paper.

09:40 Paper 9
Don Wootton - Spectro | Jet-Care

Turbine Lubricating Oil Condition Monitoring discussing Test Methods and Analysis
Modern steam and gas turbine installations place high demands on the circulating lubricating oil and none more so than when the installation is in the combined cycle. Many of the key manufacturers recommend a lubricating oil monitoring programme of some description, however even with such a programme in place

how can we be sure that the information provided allows for the optimum protection of the capital asset? Most oil related problems can lead to wear, corrosion and even filter compromise, however, there is one very serious problem that may cause none of the above - the presence of sludge and varnish. The condition can occur in even the best maintained machines. Surprisingly, it can also happen when oils are not particularly old or contaminated, it can occur with even the most thermally robust synthetic and high quality base stock lubricants. The conditions which create such deposits are many and various, but not all lubricating oil monitoring programmes have been developed to identify such issues or perhaps the testing sequences are such that the underlying conditions are simply not detected. This paper will discuss the various test methods available in the turbine oil monitoring programmes and, where there are several methods which may or may not provide key data, we will show relative comparisons and the reasons behind the selection of the most appropriate.

10:20 Coffee/tea break

10:40 Paper 10

Andrew Pym - Siemens Aero, Camberley UK

Fast Flexible Power Generation to meet the needs of changing market regulations using Siemens Enhanced Aero Gas Turbine Technologies

As the penetration of intermittent renewable sources increases, the electricity grid system needs fast flexible response to deal with their unpredictable nature.

The whole point of de-regulating energy markets was to provide “affordable” energy to industry and domestic customers alike. In recent years serious concerns have arisen due to the failure of the UK market to deliver this objective with domestic customers bearing the brunt of cost increases.

Policy makers, power generators and network operators are reconsidering the design and location of power plant to optimise network performance, and to identify other paid services in the power supply market. Operation with multiple rapid start/stop cycles and fast ramp rates are required to economically support renewables and smart grid functionality.

In this latest attempt to encourage flexible generation two significant changes have been introduced:

- Replacing RO with Contract for Difference, aimed at discouraging RO operating below marginal cost of production and at extended negative pricing > 6 hours
- The use of single punitive cash out prices to deter imbalance

It is expected that this initiative will drive the demand for fast response power plant.

Siemens are developing flexible power generation solutions using their aero gas turbine technologies to work with other grid stabilisation assets such as large scale batteries and smart grid technologies. We will illustrate this concept and how value is created in current and future balancing market rules in the UK.

This paper examines a variety of flexible power plant designs, open cycle, combined cycle and new hybrid (battery augmented) systems based around use of aero gas turbine technologies. It looks at how the technologies can be leveraged to create value in modern renewables-integrated grids, and how Siemens is investing in new technologies to further enhance their unique abilities of fast, flexible responsive power systems.

11:20 Paper 11

Dr Ulrich Orth, Dr Robert Krewinkel, Dr Sven-Hendrik Wiers, Dr Detlef Viereck – MAN Diesel and Turbo Germany

Industrial Gas Turbines for Clean and Flexible Power and solutions for International Power Generation Markets

The trend towards decarbonisation of power generation, the move towards decentralised power generation with combined heat and power applications, as well as high operational flexibility regarding choice of fuel and variation of power output to compensate for the fluctuations of power generation from renewable sources, are driving the development of gas turbines for smaller power ranges.

This paper will deal with MAN’s industrial gas turbines for the 6MW class which provide clean and flexible power for such challenging requirements.

The MGT6000 is available as a single shaft version for electric power generation, particularly in CHP applications, as well as a two-shaft version for mechanical drives. Technical design features such as advance can combustor (ACC) technology for very low NOx and CO_2 emission and the use of additive manufactured components will be explained. In addition, the result of extended string tests, which were conducted to investigate the transient behaviour of the gas turbine family, will be presented.

Beside the technical features of these gas turbines, solutions for the international power generation market will be discussed. CHP applications for different industries will be presented and the benefit of digital services such as life monitoring of machine data or trend analysis of operational data, will be demonstrated.

12:00 Lunch

13:20 Paper 12
Dr Volker Null, Shell Industry Lubricants

Oil Selection for improvements in Asset Reliability, Efficiency and Total Cost of Ownership
Turbine operators are faced to deliver enhanced productivity and to drive down operating cost of their assets under tougher operating conditions. In consequence turbine oils need to meet more stringent performance requirements over increasingly longer times than ever before. This presentation outlines how selecting and using the correct oil can help to optimise performance in service and to obtain better asset reliability and longer life, improved efficiency and reduced total cost of ownership. To achieve longer oil and asset life with improved reliability and performance, oil degradation needs to be controlled and slowed down. This limits the rate and amount of harmful deposits formed in the turbine. It will be shown how the latest base oil and additive technology used in Shell Turbo S4 X and GX turbine oils can help to extend oil life and to reduce the rate of varnish formation relative to other oils. Proactive oil condition monitoring is a useful tool to obtain asset health information in service and when combined with Shell's latest turbine oil generation helps to reduce the total cost of ownership.

14:00 Paper 13
David Bosak, Pericles Pilidis, Suresh Sampath - Cranfield University

Novel method for performance simulations of Flexible CCPP Operation
Actions against climate change are causing increasing mothballing of polluting power plants in an attempt to reduce global production of green-house emissions. The resulting gap in capacity is filled with an increasing mix of renewable/clean power generation. However, the variable nature of renewable sources presents a great and costly challenge to balance when these sources are not available (eg wind not blowing or cloudy sky). The combined cycle power plants (CCPP) provide a promising solution due to their much better load response characteristics than other technologies. The need for research to improve flexible operation of existing CCPPs has been identified in recent years. Existing techniques are broadly based on formulation of a system of non-linear equations, with numerical or sequential methods applied to solve for unknown performance variables. The difficulties in deploying these techniques to complex plant flexibility studies are described as cumbersome, time-consuming, complex, and highly dependent on an initial approximation. In this paper a novel direct solution method (DSM) is developed and presented as an alternative to existing techniques. Comparatively, the DSM requires no iterations, no initial approximation of variables, and the residual error is zero which fundamentally improves the accuracy of results. DSM can also be readily applied to simulation of multiple-pressure systems and complex optimisation of various system layouts and analysis of flexible load change strategies. The broader benefits to the power plant operator are: assessment of flexible load reduction strategies, robust modelling of plant performance at design and part load operation and cost of electricity estimations, and preliminary investigation into effects of implementing plant upgrades.

14:40 Coffee/tea break

15.00 Paper 14
Markus Kupper - Ethos Energy

Automating Optimal Gas Turbine Performance including the Tuning of Combustion Systems to maintain stability of operational performance
Lean premixed combustion systems have been deployed on land-based gas turbine engines to reduce NOx and CO emissions. These systems have been to produce emissions levels that are approximately

one to three parts per million of NOx and CO lower than unit measurement. Although these systems are a great benefit from a standpoint of emission production, several variables such as the operational envelope of the system and variation in fuel composition can also impact the cycle efficiency.

An operational envelope includes the control of fuel conditions, distribution, and injection into the combustion zones. In a lean premixed combustion system, the operational envelope has become a critical parameter that requires frequent adjustment. The required re-adjustment of the combustion fuel conditions, distribution and injection is termed "tuning."

Sufficient variation in fuel composition will cause a change in the heat release of the lean premixed combustion system and can lead to emissions excursions, unstable combustion processes, or blow out of the combustion system. Controlled operation of a combustion system generally employs a manual setting of the operational parameters at an average condition. These operational settings are satisfactory at the time of the setup, but conditions can change and cause unacceptable operation in a matter of days or even hours. Combustion tuning is required to re-adjust these conditions.

A customised tuning approach uses a formula to predict emissions based on gas turbine operating parameters. It selects a set point for fuel distribution and overall machine fuel to air ratio without modifying other parameters such as fuel gas temperature. Mis-operation of the combustion system manifests itself in augmented pressure pulsations or an increase in combustion dynamics.

15:40 Expert panel and question session

16:20 Chairman's summary and conference closing remarks

16:30 Conference Close

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