Clean and Reliable Energy Solutions

17th Symposium on Industrial Applications of Gas Turbines

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Abstracts:

Monday October 15th, 2007

1.1 - NOx CEMS and Combustion 101

Nicholas Kertesz, TransCanada

The major thrust of the paper will demonstrate that the exhaust gas volume measurement part of the RATA test, in the case of natural gas fired DLE gas turbines with F factor based CEMS systems, is absolutely pointless; a waste of resources. The RATA test should consist only of verification of NOx analyzer and O2 analyzer outputs. That would make the RATA test a much less effort and cost intensive exercise. The paper will also demonstrate that the US EPA F factor based exhaust gas volume and emission calculation formulae can be made more accurate by simply modifying the formulae.

1.2 - CLN Emission Control Technology for the RR Avon and LM2500

Dah Yu Cheng, Cheng Power Systems

CLN® technology was designed to reduce NOx and CO2 through improved fuel efficiency. In general, CLN® technology applied to aero-derivative turbines can reduce CO2 by more than 25%. The laboratory results show that CLN® can reduce NOx down to 2 ppm. An Avon engine passed TQP test requirements in 2005. The laboratory test of the LM2500 combustion system was completed in February 2006. The ongoing LM2500 work for a TQP test on a real engine should be completed by March 2007.

1.3 - The Duct Burner, an Integral Part of Your System

Daniel Lefebvre, Coen Company Inc.

A duct burner is present in the vast majority of gas turbine installations. This article will focus on the important parameters for the successful installation of a duct burner. We will look at TEG and FA applications, the importance of velocity profiles and the duct design, the emissions added by the duct burner, the different fuels possible, the effect on turbine efficiency etc. We will look at the most practical solutions to optimize the performance of the system.

1.4 - Acoustic Performance Considerations for a Once Through Steam Generator

Vince Gambino and Payam Ashtiani, Aercoustics Engineering Limited

Once-Through heat recovery Steam Generators (OTSGs) are used by electricity power plants and a host of other Industrial and/or commercial centers to recover the heat from a gas turbine exhaust stream. The OTSG is capable of dry operation; therefore a bypass stack is not required, resulting in reduced leakage and more efficient operation from a construction standpoint. This makes an OTSG very attractive as a fundamental part of a heat recovery system in a cogeneration power plant. An important property of an OTSG is its acoustical characteristics and primarily its ability to reduce gas turbine exhaust noise emissions.

This paper examines the various parameters that govern the acoustic performance of an OTSG under both steam generating and dry running conditions. In particular, the paper deals with the effects of elevated gas temperature on properties such as speed of sound, viscosity, gas flow conditions and how this affects the acoustic performance of an OTSG.

The paper will also discuss the potential for flow induced noise and vibration and acoustic control methods to aid in minimizing any potential hardware damage or degradation in the acoustic performance of an OTSG due to these effects. Measurement protocols that have been used to assess acoustic performance will also be discussed, particularly in a plant environment where a multitude of sources presents challenges in effectively isolating sound sources.

1.5 - Supersonic Ejector for Capturing Low Pressure Vent Gases From Dry Gas Seal and Re-injection into Fuel Gas Line of a Gas Turbine

Kamal Botros, NOVA Research and Technology Center
Hasan Imran, TransCanada PipeLines Ltd.

The purpose of the ejector device is to capture the gas leakage from a dry-gas seal at low pressure, and re-inject it into the fuel gas line to the gas generator (without the use of compressors or rotating elements), hence providing a means to utilize the gas that would otherwise be vented to atmosphere. Implementation of this device will also have the benefit of reducing greenhouse gas emissions to the atmosphere. The primary challenge to achieve the above goal lies in the fact that the leakage gas pressure is in the range of 70-340 kPag, while the minimum pressure required upstream of the fuel gas regulator is in the range of 2400–3300 kPag. The device consists of a two-stage supersonic ejector. The first stage is highly supersonic (nozzle exit Mach number » 2.54), while the second stage is moderately supersonic (nozzle exit Mach number » 1.72).

Several tests where conducted on various configurations of the two stages on natural gas in order to arrive at the optimum design and operating parameters. The optimum design gave an expansion pressure ratio (motive/suction) of the order of 14.0 and compression pressure ratio (discharge/suction) of around 8.1. These ratios would meet the requirement of the minimum suction and discharge pressure mentioned above.

Tuesday October 16th, 2007

2.1 - Gas Turbine and MSW Incinerator Combined Cycles for High-Efficiency Power Production

Skip Hayden and Kuanrong Qiu, Natural Resources Canada

This study involves an investigation of a range of gas turbine and municipal solid waste (MSW) incinerator combined cycles. The aims are to achieve high efficiency for energy recovery from the waste while minimizing environmental impacts, including GHG's. In these combined cycles, the topping cycle consists of a gas turbine (GT), while the bottoming cycle is a steam cycle (ST), utilizing the heat from municipal solid waste combustion. The study analyzes the viability of various combined cycles and their potential thermodynamic advantages over conventional incineration of MSW. The results show that the dual-fuel combined cycles can offer dramatically higher efficiency for power production and may provide practical solutions to problems typically associated with MSW. The net electrical efficiency for a 75 MWe (GT 30 MWe + ST 45 MWe) combined cycle power plant reaches 37.7% when the gas to

MSW input ratio is 0.65, at an MSW capacity of 300,000 ton/yr. We examined the environmental impact and showed the combined cycles could provide an effective means of reducing greenhouse gas emissions, along with conventional pollutants. The calculated capital and operating costs indicate the combined cycles for power production and waste handling could be economically competitive. Furthermore, the negative fuel cost for MSW offsets the gas price risk (currently, MSW tipping fee is $84/ton). This environmentally sound, energy-efficient concept could result in a new Canadian market for gas turbines.

2.2 - New Technique for STIG Using OTSG Heat Recovery to Improve Operational Flexibility and Cost Performance

Tim Koivu, Innovative Steam Technologies

Utilities world wide need to deal with issues of high energy cost, high capital costs and tightening environmental legislation. Steam injection (STIG) is a technique which can increase a plant's ability to produce extra power without using extra fuel and with a moderate capital investment. In this paper we present a new method of generating steam required by the Cheng Cycle commonly know as STIG, using a Once Through Steam Generator (OTSG). This approach is an improvement over the conventional method of STIG because we use waste heat from the GT to produce low cost steam. A high strength, thin walled, high temperature nickel alloy steam generator is used in the hot gas path to provide superheated high quality steam suitable for use in the GT and at a low operational cost. The paper discusses current applications of this method on several gas turbines (frame and aero-derivative) which include the GE Frame 7FA, GE LM2500 and GT11 gas turbines. Additionally the paper explores the unique capabilities of the OTSG that allow for dry running, simple operation and high operational availability.

2.3 - Life Cycle Impact of Steam Injection on the LM6000PC Turbine Blades

Hugh Jin, Liburdi Turbine Services Inc

Water or steam injection for emission control or power augmentation can impact turbine hot section component life and maintenance interval. This relates to the effect of added water on hot-gas transport properties. Higher gas conductivity, in particular, increases heat transfer to buckets and nozzles, and can lead to higher metal temperature and reduced part life. Part life impact from steam or water injection is also related to the way engine is controlled.

Life cycle impact of steam injection on the LM6000PC high-pressure turbine blade has been studied. The relationships between steam injection, engine exhaust temperature control, blade metal temperature, and corresponding life changes are analyzed. The preliminary results can be used for assessment of life cycle impact with steam injection.

2.4 - Sustainable Thermoacoustic Refrigeration System for Gas Turbine Power Plants

Kamran Siddiqui, Tayyab Ghori and Yadwinder Sidhu, Concordia University
Wajid A. Chishty, National Research Council Canada

Some recent advancement in the field of thermoacoustics has revolutionalized the way many conventional devices operate. Thermoacoustics deal with the conversion of heat energy to sound energy and vice versa. The device that converts heat energy into sound energy is called thermoacoustic heat engine and the device that converts sound energy into heat energy is called thermoacoustic refrigerator. A complete thermoacoustic refrigeration system can be created by combining the thermoacoustic heat engine and thermoacoustic refrigerator. The heat engine takes heat as an input from a thermal source and delivers sound as an output. This sound is then taken as an input by the refrigerator, which pumps heat from a cold reservoir to a hot reservoir. If the heat source to the thermoacoustic heat engine is waste heat e.g. from the gas turbine power plant, the complete system can be called a "sustainable refrigeration system".

Thermoacoustics is a new and promising area of research, which has a strong potential towards the development of sustainable refrigeration systems. There are many advantages of a thermoacoustic refrigeration system as compared to the conventional refrigeration systems. One big advantage is that the design of the system is very simple, due to which the fabrication cost is very low. Also, these devices have no moving parts. As a result, there are no chances of mechanical failures and hence, they are more reliable. Furthermore, no harmful refrigerants are required. Air or any inert gas can be used as the working fluid and thus, these devices are also environmentally friendly. We have proposed a thermoacoustic refrigeration system that operates on waste heat from the gas turbine power plant. We will present detailed characteristics of this system and discuss its feasibility for implementation into the existing gas turbine power plants.

2.5 - Siemens SGT-700 Industrial Gas Turbine, Technical Description and Experience from Operation

Anders Hellberg, Siemens Industrial Turbomachinery AB, Finspong, Sweden

Siemens' 30 MW SGT-700 gas turbine (launched as the GT10C) is now a fully commercial product and living up to the expectations of the market. The SGT-700 has passed an important milestone, having entered commercial operation in 2004. Seven units around the globe are currently in commercial operation in different applications and, to date, the four lead units have logged over 12 000 hours each of operation. Further units are under assembly. Applications for the units cover power generation, mechanical drive, offshore and onshore. The turbines operate with a DLE-combustor ((Dry Low Emissions) on both single and dual fuel. During this first period of operation no major issues have been found in any of the units delivered.

The design of the SGT-700 is derived from the 25MW two-shaft SGT-600 but with third-generation DLE combustion technology taken from the more recent 45MW SGT-800. The robust design of the SGT-600, which has accumulated over three million hours of operation, was utilized to maintain high availability and reliability and has been an excellent platform for the SGT-700 introduction.

This paper describes the first phase of operation experience following on from the comprehensive testing and verification period. It will summarize the erection, commissioning and the first fifteen thousand hours (fleet leader) in commercial operation. The paper will also discuss the benefits in different power generation applications of a modern industrial gas turbine, for example the economic potential of important parameters such as robustness and low deterioration. The environmental aspects of combustion are becoming more and more important: here, the robust design of an industrial gas turbine plays an important role, because it achieves low emissions with very little variation over time. Finally the paper will describe the market requirements for effective and rapid maintenance with the capability of fulfilling different customer requirements.

Wednesday October 17th, 2007

3.1 - Integration of OEM GT Package and Factory Testing for Reliability

Gerrick Slogar, Vericor Power Systems; Randy Zulkoski, Standard Aero Limited

Vericor is a manufacturer of the TF™40/TF™50 and ASE™40/ASE™50 3-5 MW rated aeroderivative gas turbines, utilizing the flexibility of this gas turbine engine for marine propulsion, power generation, and mechanical drive applications. Marketplace demands to deliver quality products with responsive turn times, lower costs and flexibility has motivated the outsourcing of assembly and test to Standard Aero Energy, a company who is familiar with these demands being an overhauler of a number of gas turbine engines. The outsourcing of assembly and test is an innovative concept for an OEM (Original Engine Manufacturer) and is unique to the industrial gas turbine industry. The integration of OEM gas turbine assembly and test processes into its overhaul shop in a short time frame resulted in new challenges and new systems being introduced at Standard Aero Energy.

This paper outlines how Vericor and Standard Aero Energy have partnered together to meet the cost and technical objectives for Vericor's varied marketplace. It details the facility, test cell and production system designs which were integrated in the Standard Aero Energy industrial overhaul shop, the start-up processes and qualification requirements, and outlines some of the special testing performed.

3.2 - Gas Turbine Condition Monitoring with Multiple Sensors and Data Fusion

Jeff Bird, National Research Council Canada

Investigation and development of traditional and novel sensors for engine condition monitoring are described for a test cell application. Included in the experimental investigation are infrared, audio, vibration and electrostatic sensors with high speed, parallel data acquisition. Baseline test and reference methods are described. Implanted fault tests are developed and implemented based on relevant gas turbine operating experience. For example, non-specification fuel nozzles are detected in such a way that recommendations for replacement can be made before damage is incurred. Application needs of the sensing and signal processing methods are described to ensure relevance to field installations. Recommendations are presented for development and demonstration opportunities.

3.3 - Challenges for Pipeline Compression in Canada's North - Mackenzie Gas Systems

Keith Drysdale, Imperial Oil

The Mackenzie Valley Pipeline is a proposed gas pipeline from Inuvik in the Northwest Territories interconnecting with the NOVA Gas Transmission Ltd. system in northwest Alberta. It is being designed to initially transport 34.3 Mm3/d (1200 MMscfd) in the summer months with expansion capability through the addition of compression up to 49.8 Mm3/d (1725 MMscfd). This 1200 kilometre long high pressure 30 inch buried pipeline will operate at 18.7 MPa (2710 psi), a higher pressure than current Canadian gas transmission system designs. The route traverses both continuous and discontinuous permafrost in an extremely remote and rugged environment. To prevent the melting of the permafrost that makes up a significant portion of the pipeline route, the gas is chilled. This combined with the Arctic environmental conditions of extreme cold and dark winters with hot summers and continuous sunshine presents a unique operating environment. These and other challenges unique to the Canadian North face the engineers in the design and operability of the gas pipeline compressors for the Mackenzie Valley Pipeline.

3.4 - RB211 Gas Turbine DLE / RT61 Demonstrator Experience at TCPL Nordegg

S P Broomfield, Rolls-Royce

In 1996 Rolls-Royce initiated a programme to upgrade the successful 6562 package which combined the RB211-24G gas generator and the RT62 power turbine, to increase both power and thermal efficiency. This resulted in the RB211 G-T gas generator and the RT61 power turbine together designated the 6761. The gas generator modifications included an upflowed IP compressor, an Aero Trent HP compressor, a revised 'short' combustor DLE system and improvements to turbine materials. The power turbine was completely redesigned going from 2 to 3 rotor stages. The 6761 package gives a nominal 15% increase in power and a 2% increase in thermal efficiency over the 6562.

In 2003 a demonstrator 6761 was installed at a TCPL gas pumping station in Nordegg Alberta. TCPL already operate the worlds largest fleet of RB211 packages with over 80 RB211 based units of various types and ratings. The unit ran over the next 3 years in normal operational duty and in November 2006 the gas generator was removed for a routine hot end refurbishment having completed 24,233 hours and being the lead unit of the 6761 fleet. Removal of the engine also provided an opportunity to inspect the PT whilst still installed.

The engine was returned to the Rolls-Wood overhaul facility in Aberdeen Scotland where it was inspected and a refurbishment workscope defined to enable the engine to complete a further 25-30,000 hours when a full overhaul will be conducted. Overall the engine was found to be in very good condition with little work required over that normally expected for a G rated RB211 at the same running hours. Inspection of the PT whilst still installed in the berth also identified no problems requiring repair work.

This paper summarises the design changes incorporated into the 6761 package, the operational experience at Nordegg and covers in detail the condition of the engine and PT after 24,233 hours running.