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LMS100® ADVANCEMENTS IN FLEXIBLE POWER GENERATION AND DEVELOMENT OF DRY LOW EMISSIONS (DLE) CAPABILITY

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Abstract

The profile of the energy industry is changing to meet the increasing demands for efficient and flexible products that can be integrated to the various grid systems. Having now installed several additional LMS100® units into various countries, a broader understanding on the benefits that the hybrid, inter-cooled gas turbine brings is being demonstrated for several operators. The application of the 100MWe product into both cyclic and baseload applications has provided the team an opportunity to identify and improve several key systems to further enhance the existing system for both 50 and 60Hz applications. As the fleet adds both units and hours, another significant product is being brought to market – the Dry Low Emissions (DLE) combustion alternative.

This paper will detail several recently commissioned projects and highlight the technical and commercial aspects that led to the use of the LMS100 gas turbine. Product enhancements and application details will show the breadth of flexibility afforded to owners of the inter-cooled Aeroderivative technology in applications ranging from wind balancing to desalination to Oil and Gas. The technical details on the DLE system capabilities and design will provide the participants a thorough understanding on the programs final testing validation and readiness for market entry.

1 Introduction

The global energy industry is challenged to meet the increasing demands for efficient and flexible products that can be integrated to meet system needs. Since the introduction of the intercooled LMS100® in 2005, there have been several changes to the energy industry in terms of competitive products, system needs and the application of this new technology. Having now installed several additional units in various countries and grid systems, a deeper understanding on the benefits that the hybrid, intercooled gas turbine brings is being demonstrated for several operators. Several product enhancements have been incorporated into the product, the latest being the Dry Low Emissions (DLE) combustor capability, to ensure the challenges of the next decade will be met with the latest in flexible gas turbine generation technology.

2 Intercooled LMS100®

Although flexible generation is a common reference today, that was not the case when the intercooled LMS100® program was announced in 2005 and it wasn't even defined when the program was initially conceived in 1992. From the product conception, it took ten years for the engineering teams to develop the thermal modeling and Single Annular Combustor SAC combustion system that would lead to the first turbine rig test in 2003. Upon completing the first core engine test in 2004, the mechanical and thermal performance was validated with over 60 hours of testing. The following year the gas turbine was installed in a fully functional LMS100 package, at the GE full load test facility in Houston, Texas USA, where further product validation on the support systems confirmed the system integration and performance capabilities. The general layout of the standard LMS100 factory test package is represented in figure 1.

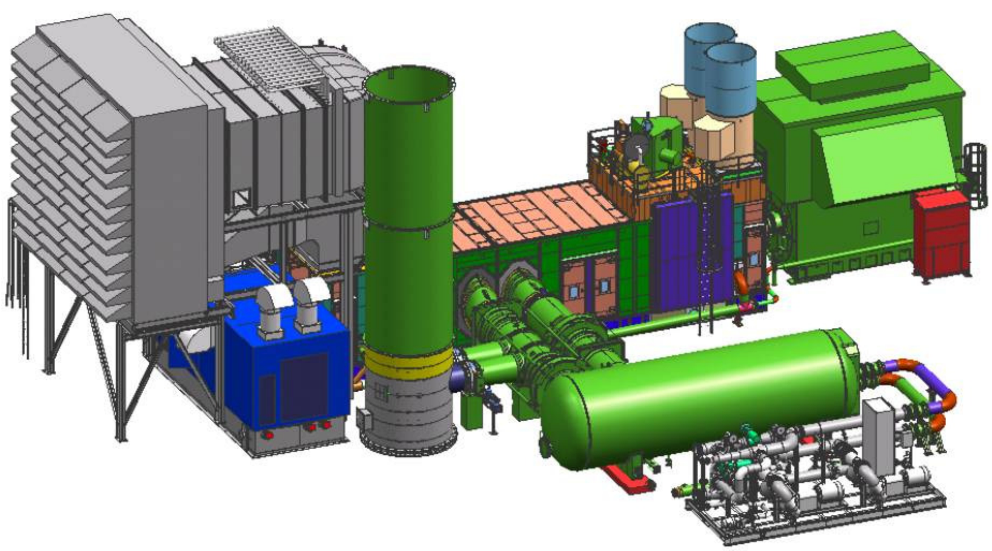

Figure 1: LMS100 factory test package layout

The most noticeable feature is the off-engine intercooler, which is comprised of the variable bleed valve exhaust system and the horizontal shell and tube heat exchanger. The system is sized to receive compressed air from the six-stage low-pressure compressor, cool it approximately 300°F and return it to the high-pressure compressor resulting in significantly higher power output versus conventional cycles. The waterside of the intercooler energy stream temperature ranges from 150C to 200C and therefore can provide up to 25MW thermal energy. A large portion of the heat rejected from intercooler can be captured and used for applications such as district heating, an ammonia chiller system or feed-water heating. Another key benefit of the intercooled system is much better hot day performance, as shown in figure 2. This benefit coupled with higher simple cycle efficiency, ten-minute starts, better part power performance and faster ramp rates have created the industry benchmark for flexible power generation.

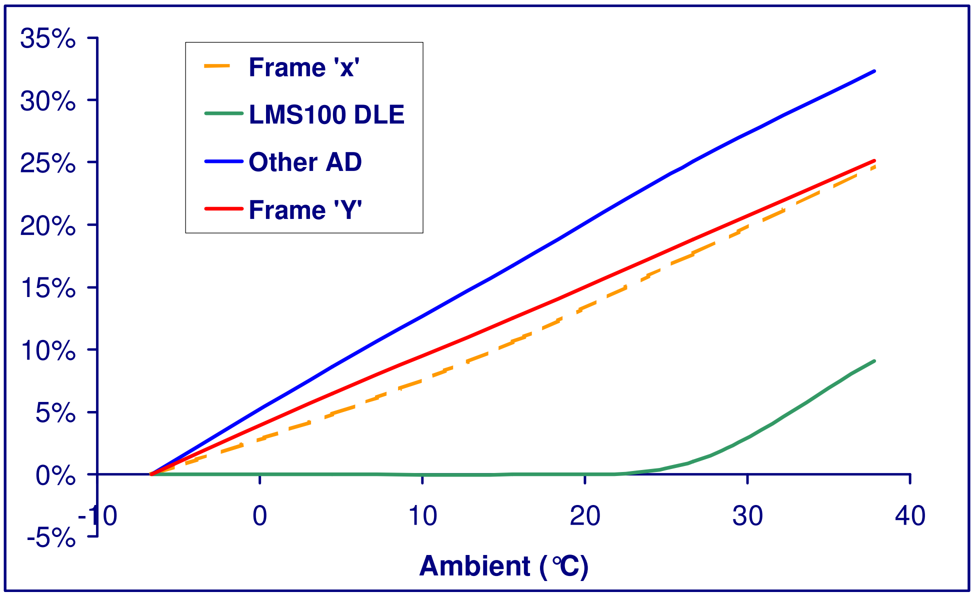

Figure 2: Power loss versus Ambient Temperature

The benefits of flexible generation have triggered high demand and acceptance in the industry enabling an accelerated fleet maturity plan, shown in figure 3. Early installations are comprised of peaking, mid-merit and base load applications in North America, South America and Europe. The first LMS100 entered service July 2006 in South Dakota USA and as a result of the successful execution and performance of the first unit; over 37 additional units have been ordered to date. The orders represent a wide range of environmental and market conditions that will further demonstrate the product's capability; ranging from –30F to over 110F. There are several installations where the gas turbine will be used for primary power as a result of its better efficiency than the existing older steam turbine units and its power fit with older combined cycle plants. Similarly, for sites located in regions with volatile power supplies there are many units that will leverage the fast 10 minute start capability to operate with several start/stop cycles and accumulate hours without impacting their planned maintenance costs.

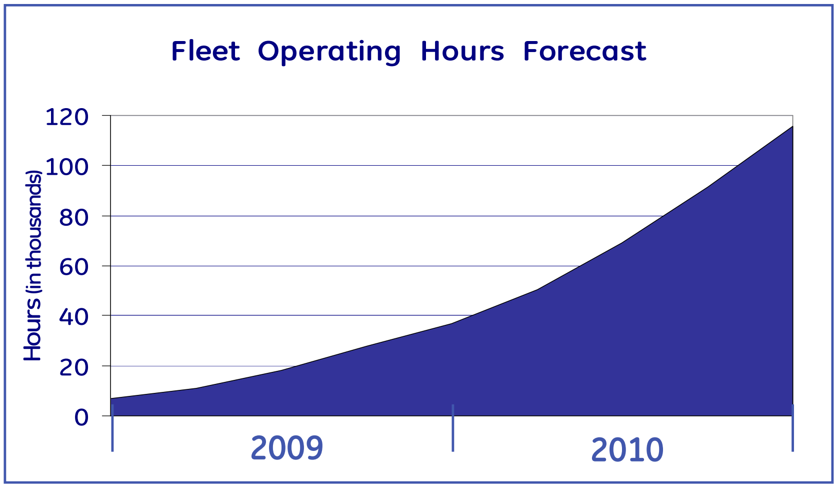

Figure 3: LMS100 Fleet Operating Hours Forecast

3 Enhancing Combustion Technology

In accordance with the GE aeroderivative design practice, the LMS100 was introduced with a single annular combustor equipped with water injection for NOx control. In a parallel effort the combustion team continued work on a dry low emissions system to enable 25 ppmvd NOx, without water injection. This effort is leveraging the proven aeroderivative multi-annular technology and experiences from GE's other aeroderivative models, the LM1600, LM2500 and LM6000. Currently there are more than 450 DLE gas turbines in operation around the world that have accumulated more than 10 million operating hours. Lessons learned from the most recent developments including enhanced heat shield design and optimized fuel distribution for improved fuel-air premixing used on the LM6000-PF and LM2500+G4 are being applied to the design of the LMS100. The LMS100 PB has a higher flow and a higher firing temperature to meet its performance requirements, but it has been validated similar to previous design using the latest advances in computational tools and component testing with a full annular rig at the GE test facilities in Cincinnati, Ohio. A significant aspect of the test plan for the LMS100 PB, was the capability to confirm the full functionality of a complete LMS100 power plant in GE's test facility in Houston, Texas. In this test facility, the unit can be tested at a full range of operating conditions from start-up to full power. Tests include sudden load changes to validate operability of the entire combustion system, including flame stability and acoustic signature.

As shown in figure 4, the required component changes from a LMS100 PA (SAC) to a LMS100 PB (DLE) are rather minimal. The LMS100 PB, as with the other LM gas turbines with DLE combustors, uses a larger combustor than the SAC model. This larger combustor provides the volume to properly mix and control the combustion flame in order to provide the high efficiency and low emissions. Leveraging the extensive experience of the GE DLE fleet, the LMS100 will utilize a dual annular premixed combustor, which will simplify the staging process and reduce the hardware required to meet the performance requirements. The balance of the package equipment and engine hardware will be identical to the LMS100 PA and will continue to benefit from experience gained on the LMS100 PA fleet.

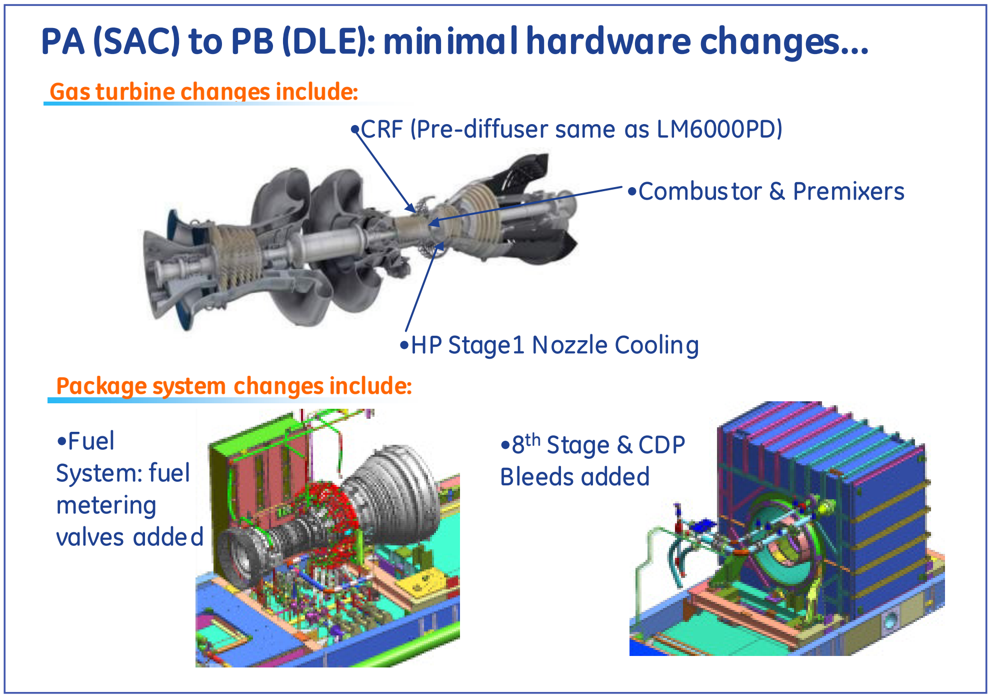

Figure 4: LMS100PB DLE hardware changes

GE expects the LMS100 PB product to benefit our customer base in the same manner as the LM6000 DLE. The LMS100 PB will provide 25 ppm NOx from 100% load down to 75% load, without using water as a diluent and there by reducing operating costs and the necessary additional permitting required. Additionally, the LMS100 PB offers customers a solution in this ever-demanding world of meeting power requirements in an eco-friendly manner while retaining the power, industry best heat rate, and the proven features of flexibility of the LMS100 PA.

GE is planning to ship the first production unit in 2010. The LMS100 PB's first engine to test was scheduled to occur in early 2009. As part of the LMS100 PB's validation program, GE has leveraged the aviation test facilities in Evendale, successfully completing multiple nozzle and full combustor tests. The performance testing of the full of the LMS100 PB power plant was expected to provide similar level of performance as the LMS100 PA without water injection.

4 Conclusions

The LMS100 has had a very successful launch and demonstration period, which has led to growing international interest in the product. Capable of providing 100MWe blocks of power with greater than 44% simple cycle efficiency, on-site maintenance capability and low ambient lapse rates is proving to meet many customers application needs. Having been evaluated and used in several diverse applications; ranging from base-load to peaking power to wind balancing, the intercooled LMS100 is changing the way people think about aeroderivatives and flexible power generation. The LMS100 is now also positioned to move into desalination and oil and gas applications. The proven flexibility of the LMS100 power plant, combined with advancement of combustion technology to include DLE capability, will enable for the further expansion of this product into new applications and markets around the world.