THE IMPACT OF FUEL GAS COMPOSITION ON GAS TURBINE OPERATION: FUTURE CHALLENGES

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It has often been said that gas turbines can burn almost any combustible gas. This has resulted in a widely held opinion that fuel composition changes are not a serious problem for gas turbine operators. While there are gas turbines running on gases ranging from Blast Furnace Gas (Lower Heating Value, LHV < 3MJ/kg) through natural gases (typical LHV 40-50MJ/kg) to high hydrogen fuels (LHV > 70MJ/kg) each individual gas turbine is designed and commissioned for a particular limited range of fuel composition. This paper considers the likely changes in future fuel composition and the impact on gas turbine operation from a combustion perspective.

Introduction

The European natural gas transmission system stretches from the North Sea and the Baltic down to the Mediterranean and from the Atlantic to Eastern Europe. It is made up of the transmission systems of different European gas companies linked by interconnections. Increased gas demand and depletion of traditional stocks are leading to a growing requirement for the transport of gas around the system and import of gas to the system. Increased imports of gas from Russia and Eastern Europe and the Near East via pipelines and from around the world in the form of Liquefied Natural Gas (LNG) have resulted in greater variations in fuel composition being delivered to some gas turbine operators. This is likely to become more common and composition variation is likely to increase. In the longer term there may be other influences on gas composition, such as the use of gases produced by the anaerobic digestion or thermal gasification of biomass or waste; or even the addition of hydrogen.

Pipeline natural gas quality and thus the fuel received by many gas turbine operators is controlled by national specifications, but these vary significantly throughout Europe (Figure 1). To aid Europe-wide trading of gas, the European Association for Streamlining of Energy Exchange (EASEE) set up a gas group, EASEE-gas, in 2002 to "develop and promote the simplification and streamlining of both the physical transfer and the trading of gas across Europe" and have produced a specification which aims to maximise the flexibility of natural gas trading.

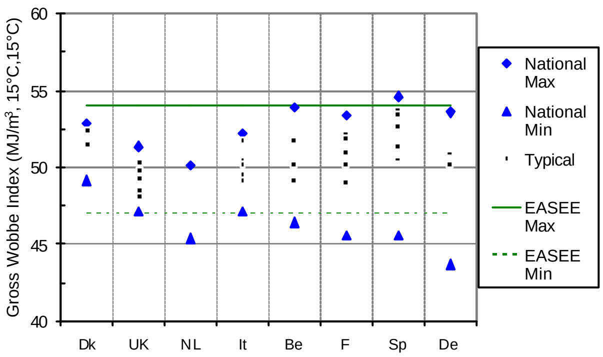

Figure 1 Typical European Gas Specifications and Compositions (Derived from References 1 and 2)

Gas Turbine Combustion

With regard to the operation of a gas turbine on a fuel of varying composition, the most significant part is the combustion system. There are various types of gas turbine combustion system, the two main types being conventional (or diffusion flame) combustors and Lean Premix combustors [also referred to as Dry Low NO_X (DLN) or Dry Low Emissions (DLE) combustors]. The majority of the gas turbine capacity installed since 1995 has some version of a lean-premixed combustion system. Lean premix combustors tend to be more sensitive to fuel variation because their operation has been optimised for a narrow range of conditions to minimise emissions of oxides of nitrogen (NO_X). Because of this and their predominance in modern power generation gas turbines, discussions in this paper will concentrate on lean premix systems. Typical features of a lean premix gas turbine burner are shown in Figure 2.

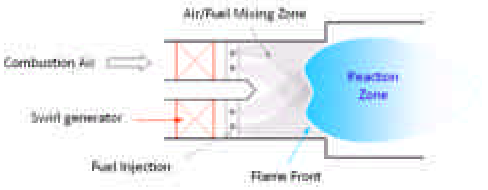

Figure 2 Typical Elements of a Lean Premix Burner

Fundamental properties of the fuel that need to be considered include heat content, flame speed, autoignition temperature, autoignition delay time, flammability limits and stoichiometric flame temperature. These together with the air fuel ratio, fuel placement and air/fuel mixing quality may have a significant influence on flame behaviour such as flash-back, blow-out, combustion dynamics and emissions. All these fundamental properties are affected directly by the composition of the fuel and changes in composition can thus directly affect flame behaviour. For example increased flame speed will tend to increase the risk of flashback. Indirect effects can also occur. For example, variations in fuel composition may affect the fuel distribution within the burner and flame by a number of mechanisms. This could lead to incorrect temperature distribution leading to increased emissions, component overheating (reducing life), increased combustion dynamics or flashback. While in principle all lean premix burners may be affected by these factors, the degree of sensitivity to each factor is dependent upon the details of the design of the combustion system and gas turbine manufacturers have a range of fuel composition requirements.

Discussion

Unfortunately manufacturers' fuel specifications are not typically published in the open literature and are often contractual documents applying to particular installations, however there is a significant amount of commonality between manufacturers' specifications and typical requirements can be determined. When these are compared to typical pipeline specifications including the EASEE-gas requirements, the major concerns for gas turbine operators are:

- The allowable variation in Wobbe Index
- The possibility of unacceptably high levels of higher hydrocarbons

Consideration of the fundamentals of gas turbine combustion together with typical manufacturers' fuel specifications leads to the conclusion that gas turbines are sensitive to natural gas composition and that many pipeline specifications including the EASEE-gas specification allow greater changes in fuel composition than can be accommodated by most modern gas turbines without re-tuning. Also fuel composition variation allowed by current pipeline specifications is greater than can be accommodated by most modern gas turbines, but this has not historically caused major problems because local variations have typically been much less than allowed by the specifications.

Conclusions

Thus significant operational problems including, excessive emissions, reduced component life or even sudden component failure may occur due to excessive fuel composition variation and the risk of such problems is likely to increase. Gas Turbine manufacturers are however starting to address the issue and a number of strategies to increase the tolerance to composition variations are being investigated.

References

1. Groenendijk W, The Global Gas Quality Perspective: The "European NGC" View, Presentation to Platts 2nd Annual Gas Quality/Interchangeability Forum, Houston, 13-14 November 2006
2. EASEE-Gas, Common Business Practice, Number: 2005-001/0, Harmonisation of Natural Gas Quality, February 2005