SIEMENS energy

Methanol: a green fuel for gas turbines

SGT-A20 Bio-methanol demonstration test

siemens-energy.com

1 Introduction

Siemens Energy in partnership with The Net Zero Technology Centre (NZTC) successfully demonstrated an SGT-A20 gas turbine running on green methanol as an alternative fuel. The world's first demonstration was conducted in collaboration with RWG at their test facility in Aberdeen, Scotland.

The use of green methanol as a fuel could significantly cut emissions from gas turbines where in the UK North Sea Oil & Gas Industry gas turbines account for around 70% of the total CO_2 emissions generated. If manufactured with hydrogen from renewable sources and captured CO_2, green methanol offers a carbon neutral fuel for gas turbines.

The demonstration test marks a milestone in NZTC's Energy Transition fund (ETF) Alternative Fuel for Gas Turbines project, which aims to pilot and develop a cost-effective, retrofittable solution for existing gas turbines to help decarbonize the power generation sector across Scotland's oil and gas operations. The success of the demonstration test paves the way for existing offshore assets to operate using low carbon fuels without extensive modifications.

2 SGT-A20 Bio-methanol demonstration test

The purpose of the test was to demonstrate the safe operation of a gas turbine running on green methanol, the auxiliary systems required to operate a gas turbine on methanol and quantify the emissions reduction and performance benefits.

A series of tests were conducted to demonstrate the safe operability of the gas turbine across the operating range. Initially, the gas turbine was tested with its standard

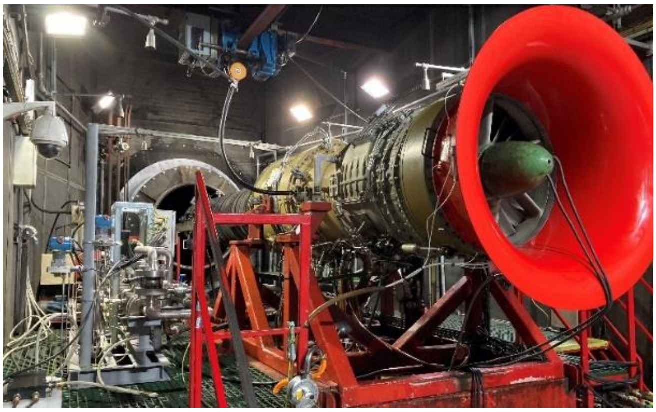

Figure 1 SGT-A20 bio-methanol demonstration test at RWG test facility in Aberdeen, Scotland

Figure 2 Bio-methanol 30,000L storage tank with nitrogen blanketing system installed RWG test facility

hardware and systems on traditional fuel (in this instance kerosene). This test acted as a baseline and provided results that can be compared to. Following this test, the modifications required to the gas turbine and auxiliary systems were made for the next phase of testing on methanol. The testing on methanol consisted of starting the gas turbine on methanol, performance and emissions testing up to full power, a normal and emergency shutdown, and transient operation on methanol. The modified hardware was also tested on kerosene to ensure fuel flexibility was maintained.

To enable the gas turbine to operate on methanol some modifications were made to both the core gas turbine and its auxiliary systems. The calorific value of methanol is around half of that of diesel (or kerosene), this means that twice as much fuel is required to get the same energy input and power output from the gas turbine. To account for the additional flow of fuel, the burners within the combustion system were modified slightly. The modification was minor and could be made whilst the gas turbine was in berth in a matter of hours.

Modifications were also made to the auxiliary systems that include: dedicated fuel storage of 30,000 liters of bio-methanol with a nitrogen blanketing system for fire prevention, a pump system to deliver high pressure methanol in the test cell, a fuel control system to control the flow of methanol to the gas turbine and also switch between kerosene and methanol fuel, and the control system to ensure the safe operation of the gas turbine on methanol. A methanol fire burns invisible to the human eye in daylight therefore, infrared fire and gas detection systems were installed to ensure the safety of all personnel during the test.

3 Results

The demonstration test allowed invaluable data to be collected to determine the effect of methanol as a fuel on gas turbine performance and emissions.

3.1 Emissions

Methanol (CH3OH) contains one carbon atom. This means that when it is combusted with air (as it is in a gas turbine) CO2 is still produced. The CO2 emissions from the direct combustion of methanol, is around 10% lower compared to diesel/kerosene. This is regardless of how the methanol is manufactured. Methanol, produced from natural gas, as it typically is today, offers a CO2 reduction of 10% compared to traditional liquid fuels, from direct combustion. However, it is important to consider how the fuel is manufactured and the associated lifecycle CO2 footprint. The demonstration test utilised bio-methanol as the fuel which has a 60% lower overall CO2 footprint. If e-methanol were to be used it would be up to carbon neutral.

In simple terms NOx emissions are very dependent on flame temperature, the higher the flame temperature, the higher the NOx emissions. Methanol burns at a much lower flame temperature compared to diesel/kerosene reducing the NOx emissions. The results from the demonstration test showed a reduction of up to 80% in NOx emissions when running on methanol fuel, as shown in Figure 3. Note, this is for a diffusion combustion system on the SGT-A20, the results may not be replicated for other combustion systems (particularly DLE systems).

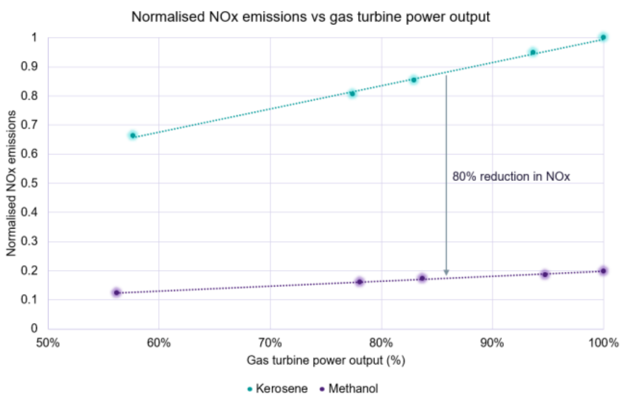

Figure 3 Normalized NOx emissions against gas turbine power output for methanol and kerosene fuel

Methanol is a pure, clean burning fuel at lower flame temperatures so there is also no SO_2 and smoke emissions and no impact to CO emissions.

Overall, methanol offers a reduction in numerous emissions species.

3.2 Performance

The properties of fuels have an impact on the performance of a gas turbine such as the power output, exhaust temperature, thermal efficiency and heat rate.

The increased mass flow of methanol fuel going through the gas turbine, combined with some changes to the gas properties, and a lower flame temperature result in a lower exhaust temperature of around 25°C, as shown in Figure 4, The reduction in operating temperature throughout the gas turbine may have a beneficial impact on the life of components. It is possible that the power output of the gas turbine could be increased by up to 10% when fueled on methanol however, further engineering analysis is required to confirm this.

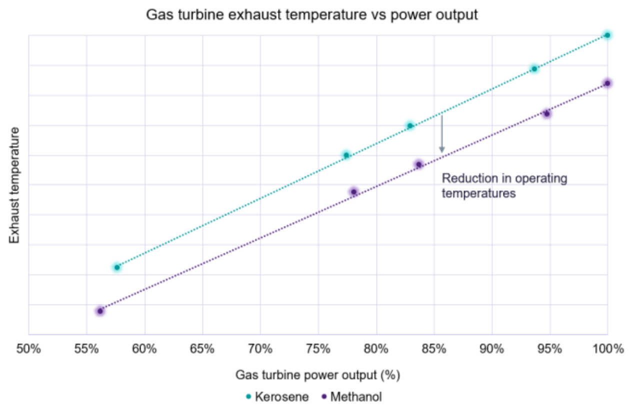

Figure 4 Gas turbine performance - exhaust temperature vs power output on methanol and kerosene fuel

Table 1 shows a summary of the key performance parameters of an SGT-A20 operating on methanol compared to diesel. Overall, methanol could provide a performance improvement by an increase in power, thermal efficiency and decrease in heat rate of the gas turbine. Note, the figures provided in this report are for information only and form no guarantee of performance of Siemens Energy equipment.

Table 1 Performance summary - SGT-A20 operating on methanol vs diesel

Parameter	Delta (methanol vs diesel)
Power	+10%
Heat rate	-4%
Thermal efficiency	+4%

The operability and safe operation of the gas turbine was not impacted by methanol. The gas turbine was tested in various operating conditions such as start-up, low to full power, shutdown, and transient operation. The gas turbine performed as expected and achieved all operating scenarios on methanol within the standard operating limits of the gas turbine.

4 Summary

Siemens Energy in partnership with The Net Zero Technology Centre (NZTC) successfully demonstrated an SGT-A20 gas turbine running on green methanol as an alternative fuel.

The demonstration test successfully proved the safe operation of a gas turbine running on green methanol as a fuel including start up, part load, full power, shutdown and transient operation and the auxiliary systems such as fuel system, fire and gas detection and control system modifications required to enable the safe, reliable operation of the gas turbine.

Methanol offers significant benefits in terms of NO_x reduction, compared to diesel fuel, of up to 80% for non-DLE gas turbines and reductions in CO, SO_2 and smoke. The direct combustion of methanol results in 10% less CO_2 compared to diesel and green methanol reduces the overall lifecycle CO_2 up to carbon neutrality.

The demonstration test yielded positive results for methanol as an alternative fuel for gas turbines with significant emissions reduction which could play a key part in the decarbonization of the UK and Global Oil & Gas industry.

Published by

Industrial Turbine Company (UK) Limited

Tachbrook Park
2 Olympus Ave
Warwick

United Kingdom

For more information, please visit our website
siemens-energy.com