Testing and analysis of the impact on engine cycle parameters and control system modifications using hydrogen or methane as fuel in an industrial gas turbine

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Aviation and power generation industry has need of efficient, safe and low-pollution propulsion systems. Against this background the Gas Turbine Section of the Department of Aerospace Technology at Aachen University of Applied Sciences works in the research field of low-emission combustion chamber technologies and investigates the complete system integration of combustion chamber, fuel system and engine control software. Especially hydrogen and methane as future green and sustainable gas turbine fuels produced by renewable energy sources such as solar energy, wind power or biomass are in the focus of the research activities. As experimental test rig an aircraft Auxiliary Power Unit Honeywell/Garrett GTCP 36-300 (Figure 1) is used. This single shaft engine requires about 1.6 MW thermal energy and produces electrical and pneumatic power provided by an auxiliary generator and an additional load compressor. The APU is modified for operation from liquid kerosene to gaseous hydrogen and methane. The conversion bases on the concept of feeding always the same requested amount of thermal energy into the combustion chamber achieving similar gas turbine operation characteristics. In [1, 2, 3, 4] the successful implementation of a metering unit for gaseous fuels (Figure 2), the modification of the fuel control system and the re-programming of the VECB (engine controller) for hydrogen is described. Reference [2] shows the start-up and acceleration behavior with hydrogen.

Figure 1: APU GTCP 36-300 on test rig

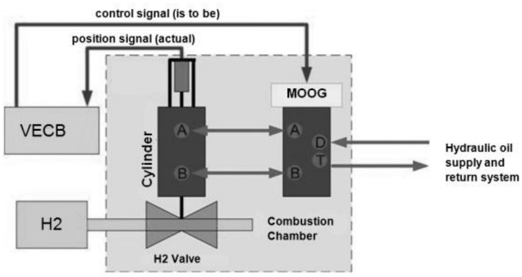

Figure 2: Metering unit for gaseous fuels

Based on this experience, the paper presents the successful conversion of the APU from gaseous hydrogen to gaseous methane at part load and maximum load operation without changing the fuel injectors in the combustion chamber. Hydrogen and methane have very different properties, e.g. heating value, air requirement, flame speed and chemical reactivity. Therefore, the change from hydrogen to methane has an impact on the combustion characteristics and the thermodynamic gas turbine cycle influencing the engine control behavior. The paper highlights the modification of the engine control software allowing safe and accurate methane operation achieved without any mechanical changes of the metering unit. Exemplarily, figure 3 shows the measured resulting acceleration and deceleration characteristics of the engine controller behavior from idle to maximum load operation mode MES (Main Engine Start) comparing hydrogen and methane. Methane shows a more distinct reaction to the load change than hydrogen and requires a longer time until a constant rotational speed is established after the load change. The control behavior is analyzed more in detail in the paper. The change of the used fuel significantly influences the thermodynamic cycle of the gas turbine [5] and e.g. therefore an EGTbased control system has to be modified. A theoretical analysis of the thermodynamic cycle is presented in the paper supported by a gas turbine cycle simulation using the software GasTurb validated against experimental results of the gas turbine operating with hydrogen and methane.

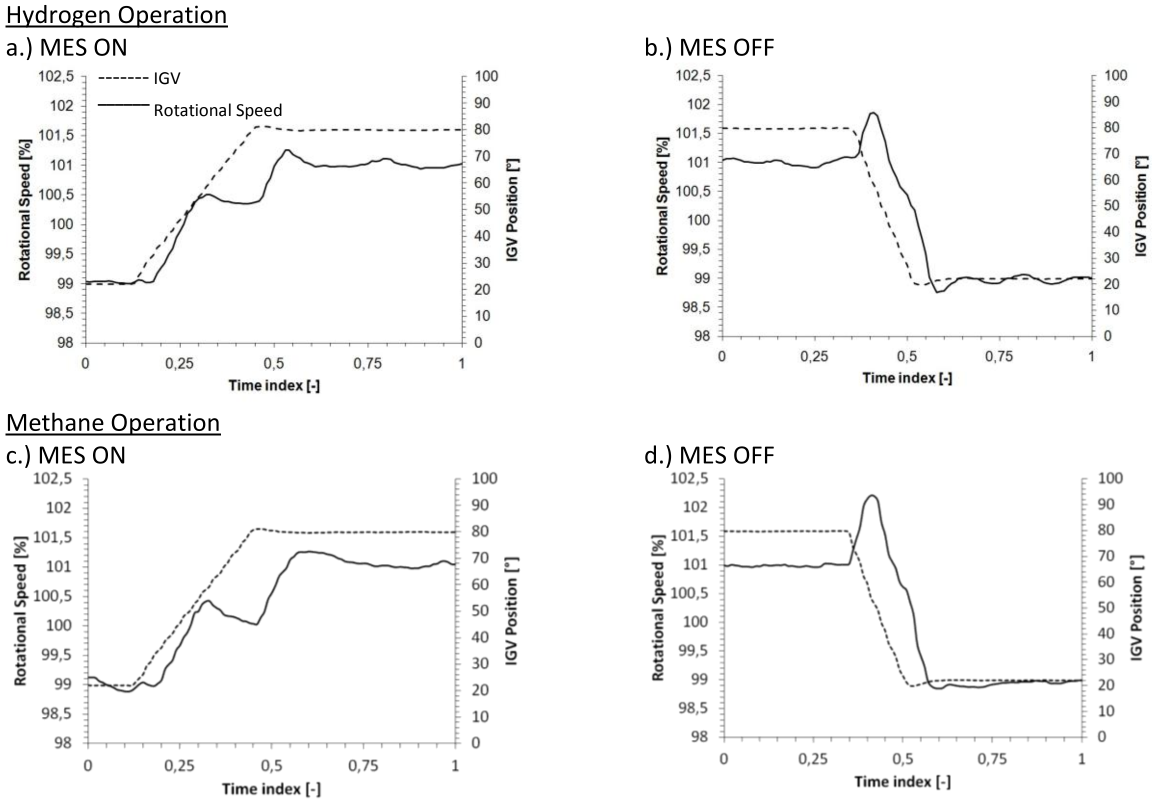

Figure 3: Acceleration and deceleration behavior of the engine controller for MES of hydrogen and methane

References:

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