Compact reformer/burner module for small scale LPG powered fuel cell APUs

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Introduction

A fuel cell auxiliary power unit (APU) using liquefied petroleum gas (LPG) for mobile applications is currently being developed at the Centre for Fuel Cell Technology (ZBT). The integrated fuel processor consists of a reformer/burner module and a CO-purification module producing 1 kW_{el} at nominal load.

The innovative reformer/burner module includes a water evaporator, several heat exchangers and as its main part a combined steam reformer and catalytic burner reactor based on metallic structures. The burner fulfills three tasks: If functions as a start up burner, as an anode-off gas burner and as a supplier for the necessary steam reforming reaction heat.

Start up concept

At ambient temperature the catalytic burner does not produce any heat due to the ignition temperature of the LPG/air mixture of 250 °C in presence of an adequate catalyst. For the necessary preheating no hydrogen or anode-off gas is available and no electrical heating should be utilized.

As solution to this problem a new method for reformer start cold was developed by simply employing a sparking plug at the outlet of the catalyst burner and operating the catalytic burner as flame combustor.

Start up sequence

1. Initial ignition of LPG/air mixture by the sparking plug at burner reactor outlet
2. Monolithic structure functions as a flow distribution plate and as flame barrier
3. A stable flame appears at burner reactor outlet
4. Burner reactor structure is heated up in counter flow direction
5. Start of catalytic oxidation by reaching activation temperature
6. End of flame combustion due to upstream catalytic conversion of burner feed

Cold start up is demonstrated with a non insulated test reactor. The three sequences ignition and flame combustion at the burner reactor outlet after 2 minutes, the transition to catalytic oxidation after 9 minutes and the complete catalyst activation after 14 minutes are visualized with IR-camera pictures.

The following start-up procedure tests were conducted with the reformer/burner module.

Result of dynamic operation in the load range from 60 - 100%:

- fast transient response of the reformer/burner module at a load change velocity of 2 W/s
- constant hydrogen power output
- steady efficiency above 60 %
- exhaust gas composition: <5 ppm CO, H₂, NO and 0.2 % CH₄, and 0.3 % C₃H₈

Summary

The proceeding development of ZBT’s LPG based APU led to a new start up method and an optimized automated operation of the reformer/burner module with the following features:

- Development of a start up procedure with a sparking plug
- and the single catalytic burner operated in flame and catalytic mode
- Start up time < 25 minutes
- Automated operation of reformer/burner module and mobile gas process
- efficiency above 60 % during dynamic and steady state operation
- Patents are currently pending

Further development

The start up procedure still has to be optimized concerning reduction of emissions and duration. Furthermore the requirements for heating up the downstream CO-purification module and fuel cell have to be considered.

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