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Project acronym: GaSTech

Project title: Demonstration of Gas Switching Technology for Accelerated Scale-up of Pressurized Chemical Looping Applications (GaSTech)

Starting date of project: 1st of August 2017

Duration: 36 months

WP N°	Del/ Mil N°	Title	Contributors	Version	Lead beneficiary	Nature	Dissemin. level*	Delivery date from contract dd/mm/yyyy	Actual delivery date dd/mm/yyyy
2	2.4	GSC demonstration in the cluster	SINTEF		NTNU	Report	PU	31/12/2020	30/12/2020

***Dissemination Level**		
PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

1 Introduction

The proposed plan is to demonstrate continuous autothermal operation of Gas Switching Combustion (GSC) using a cluster of three reactors. The previous studies on Gas Switching Technology (GST) have been completed using a single (1 kW_{th} capacity) lab-scale fluidized bed reactor of 5cm ID which does not operate continuously. Based on this, the GST standalone reactor was scaled up to a 50kW_{th} pre-pilot cluster (***Figure 1***) of three identical reactors (10cm ID each) to operate in an automated manner for a continuous supply of products gas to a downstream process. The working principle is to alternate different redox stages among the three reactors to achieve pseudo-continuous operation (***Figure 1a***). The setup can withstand up to 1000°C and 20bar. A lance was designed to feed gas towards the bottom of the bed to achieve fountain-like gas distribution for good fluidization of gases across the bed. The first-of-its-kind unit was first applied to chemical looping combustion using a CaMn-based oxygen carrier that has extensively been tested in a previous study in the small-scale reactor. The ultimate aim of this task is to achieve autothermal operation at high pressure up to 15bar in addition to understanding the interactions between the individual reactors in operation, and implementing the different operational strategies to include in the commercial scale.

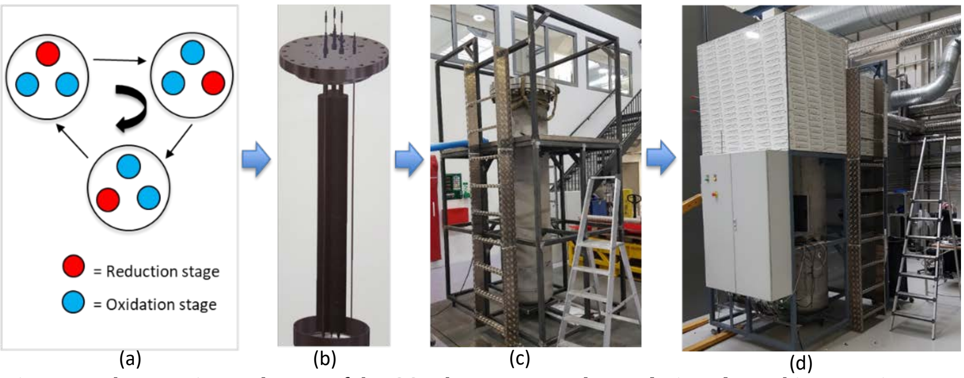
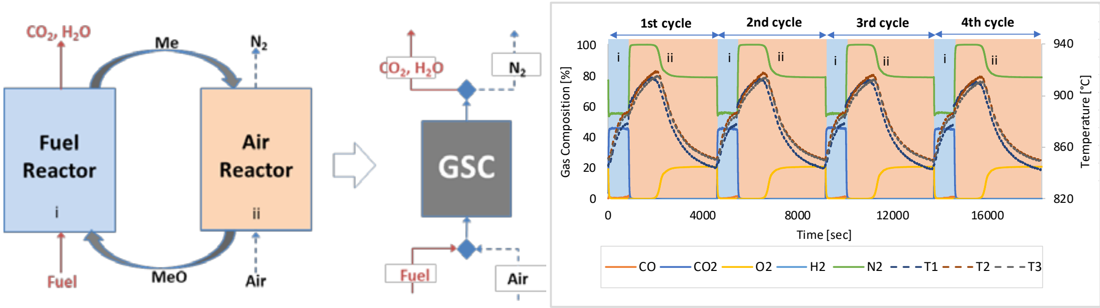


Figure 1: The experimental setup of the GST three-reactor cluster designed to achieve continuous operation. (a) the working principle where each circle represents one reactor in a different redox stage; (b) the symmetrical arrangement of the three identical reactor cluster (c)the experimental setup under construction; (d) the commissioned setup.

2 Results

Autothermal (without external heat supply) gas switching combustion was demonstrated in each of the reactor cluster as a two-stage process ***(Figure 2a)*** using CO as fuel under atmospheric conditions. The gas composition and temperature profiles were repeatable over several cycles ***(Figure 2b)***. Complete conversion of CO was achieved with about 99.99% CO_2 purity and 98.9% CO_2 capture efficiency. No CO_2/CO was observed in the oxidation stage ***(Figure 2b)***, indicating no carbon deposition. However, particle elutriation was a major problem that hampered the automated pressurized cluster operation. Further optimization of the design is recommended for automated pressurized operation.



(a) *(b)*

Figure 2: (a)Gas switching combustion process, (b) The autothermal transient gas composition and temperature profile of Reactor 1 at 850°C and 1bar. The reduction/fuel stage is indicated as i (blue) while the oxidation stage is indicated as ii (pitch). T1, T2, and T3 are temperature measurements at the bottom, centre, and top of the bed inside the reactor. For each cycle, the flowrate at the fuel stage is as follows: CO (20nl/min) and N_2 (15nl/min) for 15 min at the reduction/fuel stage while 30nl/min of air was fed in the oxidation stage for 75min.

3 Conclusion

Although the commissioning of the cluster was successful, there are still some technical challenges associated with continuous pressurized operation. Particle elutriation was a major problem that hampered the automated pressurized cluster operation. However, this problem can be solved by modifying the reactor vessel design to incorporate freeboard or increasing the particle size of the oxygen carrier to avoid elutriation.

4 References