Project ID: 271511

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	2.5	GSC with optimized OC	SINTEF		NTNU	Report	PU	10/05/2019	12/05/2019

***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 the concept of Gas Switching Combustion (GSC) using optimized $CaMnO_{3-\delta}$-based oxygen carrier in gas switching reactor cluster. The GSC concept has been demonstrated in a single reactor using different oxygen carriers (Ni-based, ilmenite and $CaMnO_{3-\delta}$-based) and fuels (CO, H_2 and CH_4), under atmospheric and pressurized conditions [1-3]. These studies have shown very attractive features, such as ease of operation and control under pressurized conditions, in addition to sufficiently high CO_2 purity and capture efficiency. An optimized $CaMnO_{3-\delta}$-based oxygen carrier was developed in WP1 for autothermal GSC demonstration in the reactor cluster.

The screening test of five samples of the optimized $CaMnO_{3-\delta}$-based oxygen carrier with tap densities from 1.990, 2.034, 2.093, 2.191 and 2.290 g/cm^3 have been completed. Experiments were conducted in the 5cm standalone fluidized bed reactor.

2 Results

The first screening of the $CaMnO_{3-\delta}$-based oxygen carrier with tap density 1.86g/cm^3 (Figure 1) revealed good performance in terms of reactivity 850°C and atmospheric pressure. However, the mechanical stability was not optimal leading to much degradation (about 20%) due to attrition (*Figure 2*). To improve the mechanical strength of this material, EuroSupport- WP1 has synthesized five optimized samples calcined at higher temperatures in order to increase the tap densities. A compromise was however made between the high reactivity and mechanical stability.

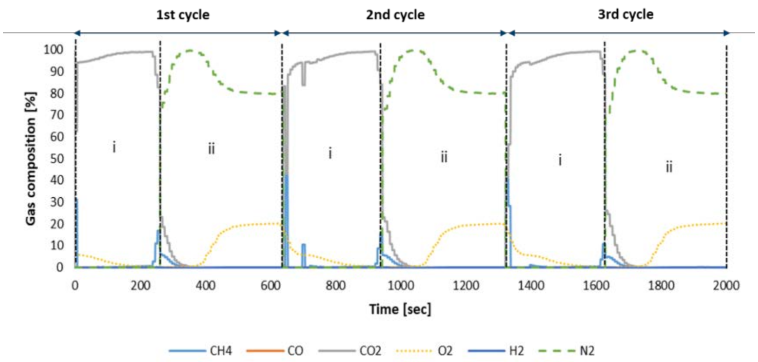

Figure 1: The behavior of the GSC concept over 3 cycles with CH_4 and air using $CaMnO_{3-\delta}$-based oxygen carrier at 850°C and atmospheric pressure. i and ii represent the reduction and the oxidation stages respectively.

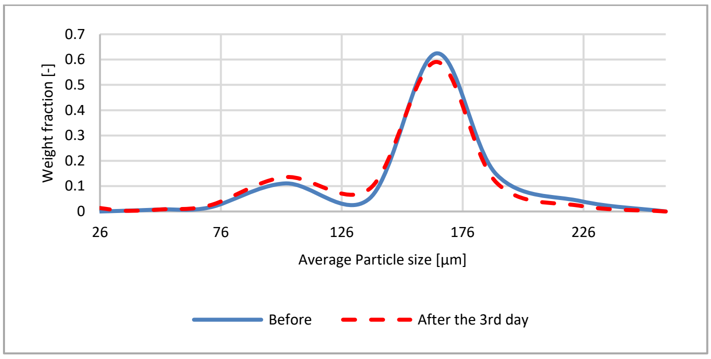

Figure 2: The Particle Size Distribution (PSD) before and after the 3rd day (over 50hours GSC experiment) using CH_4-and air with the optimized $CaMnO_{3-\delta}$-based oxygen carrier sample (tap density of 2.093g/cm^3) from 850 to 950°C and atmospheric pressure.

The sample with tap density 2.093g/cm^3 showed the best performance in terms of reactivity and attrition resistance. At the first day of screening, good performance was observed in terms of reactivity, showing stable redox cycles with almost complete CH_4 conversion during the reduction stage at 850°C and atmospheric pressure. However, lower CH_4 conversion was achieved during the second and the third day tests after cooling down the reactor. This could be a sign of structural change that could occur while cooling down the oxygen carrier. An additional stability test was completed for the same sample at higher temperature up to 950°C which improved back methane conversion with stable cycles. More CH_4 slippage was observed with the samples with higher density. This may be due gas diffusion limitation as the particle becomes more compact preventing the gas to permeate into the active sites.

3 Conclusion

Although the optimized material was reactive and exhibited good performance towards gas switching combustion, particle attrition was still imminent. Efforts were made to further increase the tap density of the oxygen carrier to improve the mechanical stability but was counteracted by reduced activity.

References

1. Zaabout, A., S. Cloete, and S. Amini, *Autothermal operation of a pressurized Gas Switching Combustion with ilmenite ore.* International Journal of Greenhouse Gas Control, 2017. **63**: p. 175-183.
2. Zaabout, A., et al., *Experimental Demonstration of a Novel Gas Switching Combustion Reactor for Power Production with Integrated CO2 Capture.* Industrial & Engineering Chemistry Research, 2013. **52**(39): p. 14241-14250.
3. Zaabout, A., et al., *A pressurized Gas Switching Combustion reactor: Autothermal operation with a CaMnO3−δ-based oxygen carrier.* Chemical Engineering Research and Design, 2018. **137**: p. 20-32.