Investigation of candidate materials as oxygen carriers in Chemical Looping Combustion process (CLC). Fluidized Bed Reactor Configuration.

Laboratory of Environmental Fuels and Hydrocarbons (LEFH) CPERI-CERTH

The Laboratory of Environmental Fuels and Hydrocarbons (LEFH) of Chemical Process and Energy Resources Institute (CPERI), which is part of Center for Research and Technology Hellas (CERTH) purchased a split tube furnace from Thermansys company, equipped with unique high density Kanthal SiC resistors in order to be able to heat up to 1500°C continuously. The model was RCT-AS1-O –D6/L30-1500 and the appropriate controller for the furnace was included. The specific model was preferred due to the high required temperatures (1000-1200 ^{o}C) of the application that it was purchased for.

The furnace was utilized in an experimental bench scale unit, where a reactor was installed with fluidized bed configuration. The scope of the project was to investigate candidate materials as oxygen carriers in Chemical Looping Combustion process (CLC). Using the reactor thermocouple as feedback for temperature control, a control option provided by Thermansys controller, was very useful to achieve necessary accuracy and repeatability. The novelty of CLC is the inherent CO_2 separation from the flue gases. Usually, high cost processes are applied for the separation of CO_2 from flue gases in order to exploit it or even store it, so that it won't be released in the atmosphere, as CO_2 is severely contributing to the greenhouse effect.

Basic concept of CLC is illustrated at Fig. 1. Oxygen carrier circulates between an air and a fuel reactor. In the air reactor, the oxygen carrier is oxidized, which is always an exothermic reaction. The air reactor has inlet from air and outlet of depleted air. The outlet contains nitrogen and a decreased amount of oxygen. The outlet is also hotter than the inlet because of the exothermic reaction. These gases can be released without harm to nature. The oxygen carrier flow is taken to fuel reactor where a reduction reaction takes place. The reduction reaction can be either exothermic or endothermic depending on the oxygen carrier. Fuel is the inlet for fuel reaction and the outlet contains mainly CO_2 and small amounts of H_2O. This way, almost pure CO_2 is obtained after steam has been removed by condensation.

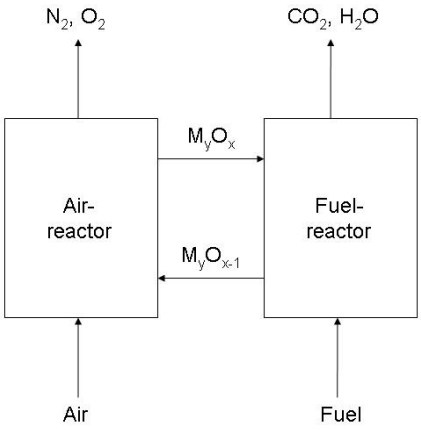

Fig. 1 Basic concept of CLC-process and oxygen carrier circulation

The experimental set up of CPERI utilizes a single fluidized bed reactor. The reactor was designed and manufactured by high purity quartz material due to its higher thermal resistance compared to the conventional quartz. The overall schematic diagram of the unit is presented in Fig. 2 and a picture of the installed furnace in Fig. 3. The THERMANSYS furnace is capable for the high temperatures (1000 ^{o}C) necessary for the CLC process. A Mass Spectrometer (MS) is used for the analysis of the reactor outlet gas stream. The cycles are realized by switching between reductive and oxidative gas flows via separate mass flow controllers.

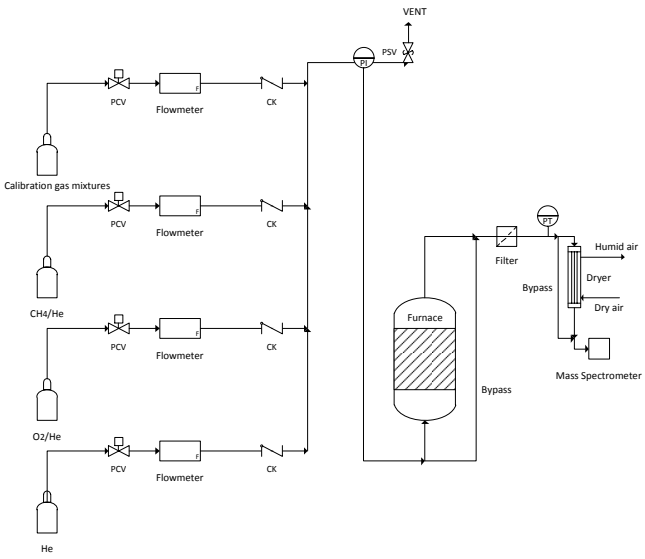

Fig. 2 Schematic diagram of the experimental unit for CLC process

Fig. 3 Installed THERMASYS furnace and quartz reactor of the experimental unit for CLC process

Published Articles and Presentations in Conferences

- Antonios C. Psarras, Eleni F. Iliopoulou, "Investigation of mineral oxygen carriers for Chemical Looping Combustion process" Recent Advances in Mechanics, Mechatronics and Civil, Chemical and Industrial Engineering (2015) p96-100

- Antonios C. Psarras, Eleni F. Iliopoulou, Antigoni Evdou and Lori Nalbandian, "Attapulgite as Oxygen Carrier for Chemical Looping Combustion" in 24th North American Meeting (NAM) of the Catalysis Society, June 14-19, 2015 Pittsburgh, Pennsylvania, USA.

- Attapulgite mineral as oxygen carrier for the Chemical Looping Combustion, A.C. Psarras*, E.F. Iliopoulou, A. Eudou, L. Nalmpantian, 3rd International Conference on Chemical Looping, 09-11/09/2014, Gothenburg Sweden

- Utilization of Attapulgite mineral as an oxygen carrier for the Chemical Looping Combustion (CLC) process, A.C. Psarras*, E.F. Iliopoulou, A. Eudou, L. Nalmpantian, 10th Panhellenic Chemical Engineering Conference,, 04-06/06/2015, Patras, Greece.