Cold flow experimentation of 1.5 MW Chemical Looping Combustion unit

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Introduction

- Chemical Looping Combustion (CLC) is an oxy-combustion technology for CO_2 capture.
- Benefits are low energy penalty and CO_2 avoidance cost[1].
- CHEERS project aims demonstration of a CLC pilot at 3 MW scale.
- An equivalent of 1.5 MW_{th} cold flow model was designed and built to study the hydrodynamics.

	Reference CFB unit	Amine MEA30%	CLC
Net Electric production (MWe)	630	630	630
Net Electric yield (%)	44.9	34.9	**40**
Coal consumption (t/h)	198	255	222
Capex (M€)	1215	2064	1785
Opex (M€)	156	220	206
Cost of Electricity (€/MWh)	63	98	88
CO2 avoidance cost [€/t/CO2]		53	**37**

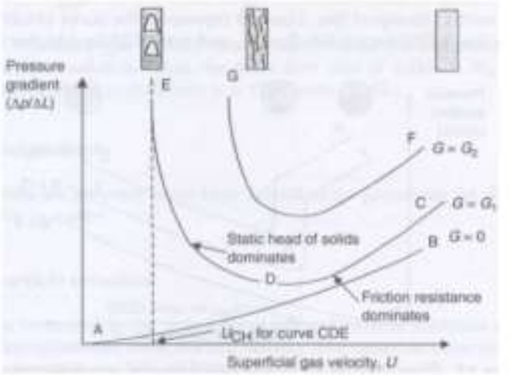
1) *T. Gauthier et al. (2017) Powder Technology, 316,3 -17*

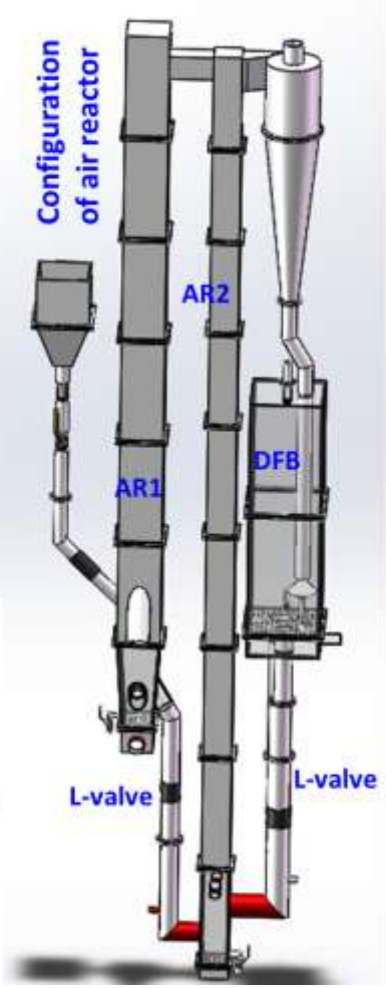
Objectives

- The cold flow model experimentation aims to study :
  - Transport of oxygen carrier in air reactor
  - Fluidization of oxygen carrier and Petcoke in fuel reactor
  - Solid circulation control between air reactor and fuel reactor
  - Carbon stripper efficiency
- Dimensions are significant for hydrodynamic characterization.
- First experimental campaign was performed and preliminary results are presented.

Air reactor and Dividing fluidized bed

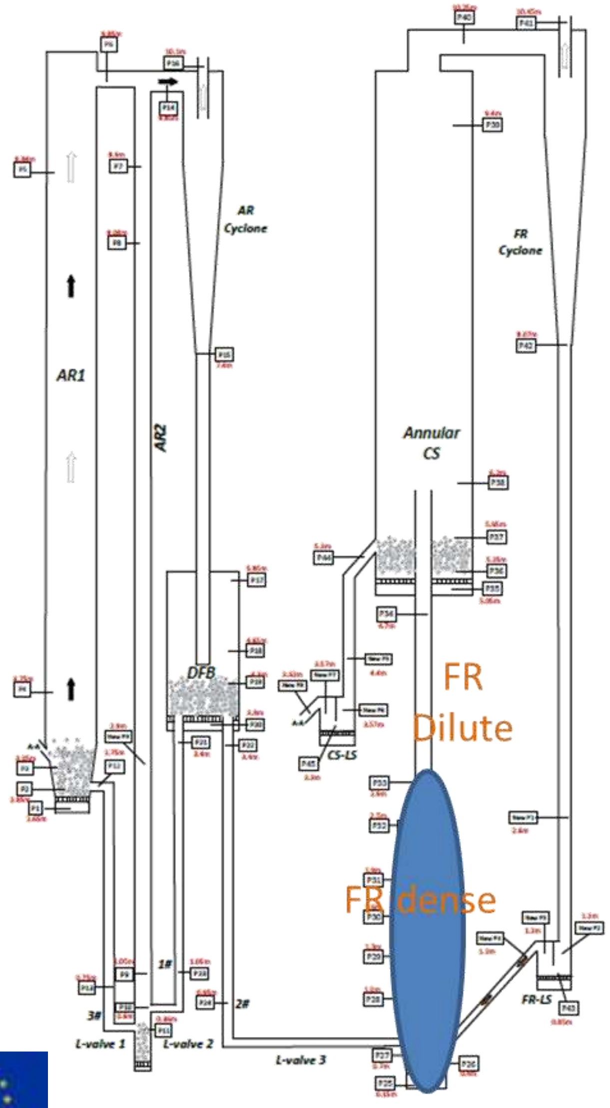
- The AR was designed with two sections in order to have the maximum flexibility of operation:
  - AR1 can be operated as a bubbling/turbulent or fast fluidization flow regime (Inspired by the current operation of a boiler)
  - AR2 represents a riser operating in transport regime.
- The AR section was studied by different Ugs and different solid fluxes to have indication on the hot pilot operation.
- The dividing fluidized bed is a part of IFPEN/Total design for controlling the recycle ratio in the AR2 and the solid flow to the Fuel reactor

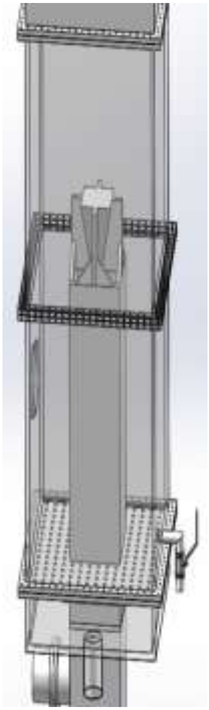




Fuel reactor, Carbon Stripper and solid circulation

- Dense section and dilute section :
  - Dense fluidization to assure proper mixing between the injected solid fuel, OC and fluidization gas
  - Riser to transport to the Carbon stripper
- Solid flow is controlled by L-valves between AR and FR.
- The entire loop is equipped with pressure measurements.





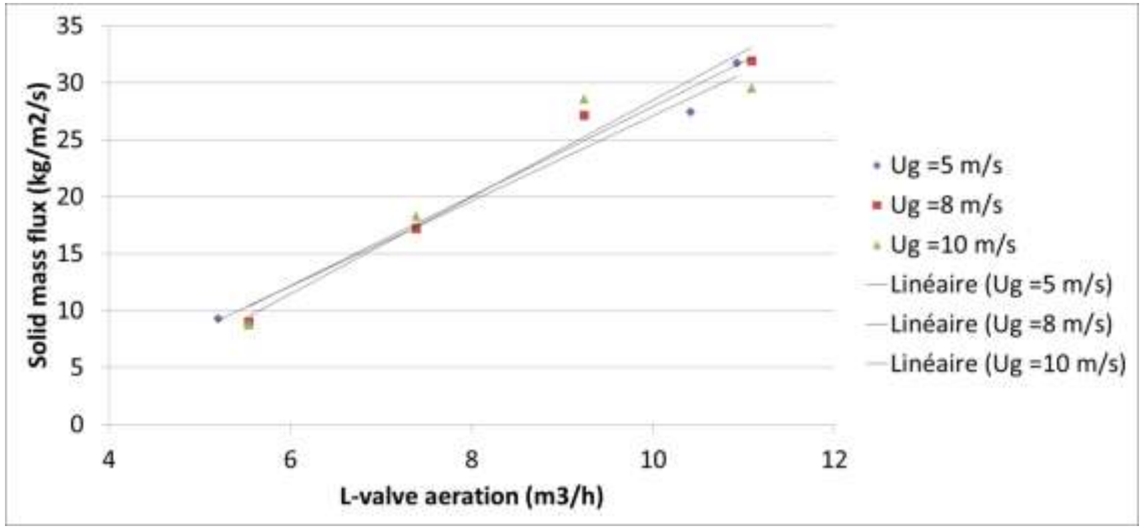
Solid circulation

- Step by step circulation was performed in the entire loop.
- The L-valves design and operation was based on previous works at IFPEN[1].
- Solid circulation was first calibrated by operating the L-valve between DFB and AR2.
- The stable solid circulation was achieved by opening the L-valves and loop seals.

1) *Yazdanpanah, et al. (2012) Powder Technology, 221, pp. 236-244.*

Quantitative results

- Stable solid flux achievable in the AR riser (AR2) was investigated by changing the superficial gas velocity and L-valve solid feeding.
- The solid flux of around 30 kg/m2-s was achieved with a riser velocity of 5 m/s. Higher solid fluxes would have caused choking.
- Ug's higher than 6 m/s assured a smooth solid circulation in the riser.



Quantitative results

- FR was operated at three superficial gas velocities (0.7, 1 and 1.5 m/s) with different solid circulations in the entire loop ranging from 0.5 to 3 kg/s.
- The sensitivity of FR dense phase height to the solid circulation and gas velocity was evaluated:

Gs (kg/s)	FR Ug (m/s)	H FR (m)
A	1.0	B
0.23*A	1.0	B-0.2
1.2*A	1.0	B+0.6
0.4*A	1.5	B-1.1
1.2*A	1.5	B+0.1
0.4*A	0.7	B+0.5

Conclusions and perspectives

- Cold flow model with representative dimensions was built and operated.
- Stable and controlled solid circulation using L-valves was achieved.
- Hydrodynamic study of AR, DFB, Cyclones and FR sections performed.
- Carbon stripper efficiency and solid-solid mixing in the FR are ongoing research.

Thank You!

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