POST-COMBUSTION CO_2 CAPTURE: Global Process Simulation and Solvent Degradation

G. Léonard[1], H. Lepaumier[2], F. Blandina[2], M.-L. Thielens[2], D.Toye[3], G.Heyen[1]

[1]Laboratory for Analysis and Synthesis of Chemical Systems, B6a, University of Liège,
[2]Laborelec, Rodestraat 125, 1630 Linkebeek,
[3]Laboratory of Chemical Engineering, B6c, University of Liège
Corresponding address: g.leonard@ulg.ac.be

Abstract

One of the biggest upcoming challenges concerning both environmental and energy systems engineering is the control and limitation of greenhouse gas emissions due to human activity. Fossil fuels-fired power plants are in this context one of the main contributors due to the large amounts of CO_2 emitted. Different technologies are developed for capturing CO_2 from such power plants. This work focuses on post-combustion CO_2 capture by reactive absorption of CO_2 into amine solvents like 2-ethanolamine (MEA). Two main aspects are considered: process modelling and solvent degradation since amine solvents are susceptible to degrade, inducing important additional costs. The objective is to perform a multi-objective optimization of the capture process and to propose operating conditions that will minimize the process energy consumption as well as the environmental impact due to solvent degradation.

Model description

CO_2 contained in the power plant flue gas reacts with amine solvents in the absorber. The flue gas exiting the capture plant after washing contains 90% less CO_2. The rich solvent is pumped to a stripper where it is regenerated at higher temperature, releasing an almost pure CO_2 flow. The regenerated lean solvent flows back to the absorber.

To model the CO_2 capture process, there are two different approaches:

- **Equilibrium**: Column stages are in thermo-dynamical equilibrium
- **Rate-based**: Mass and heat transfer as well as kinetics limitations are considered. Since this model is more precise, it has been used for further calculations.

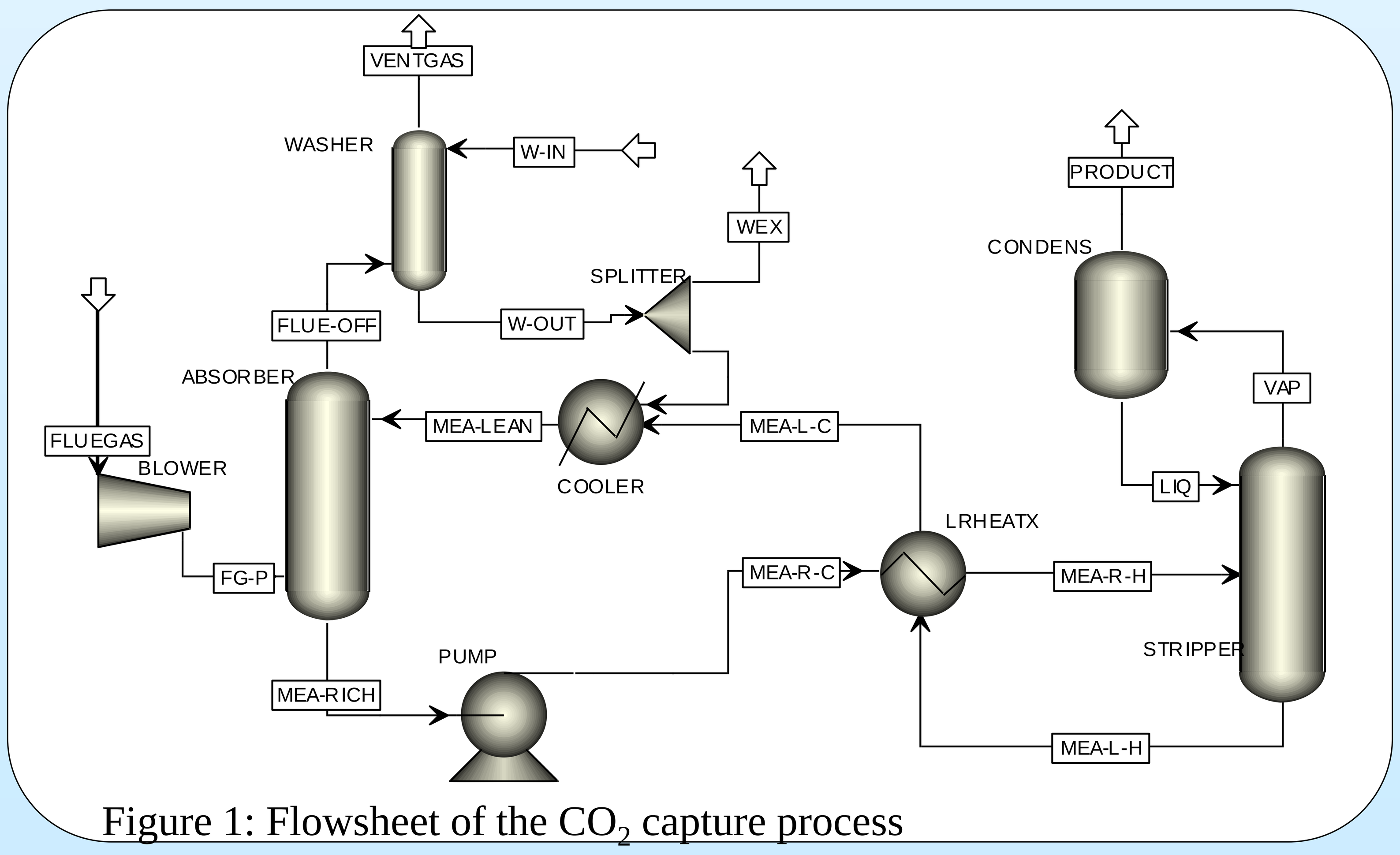

Figure 1: Flowsheet of the CO_2 capture process

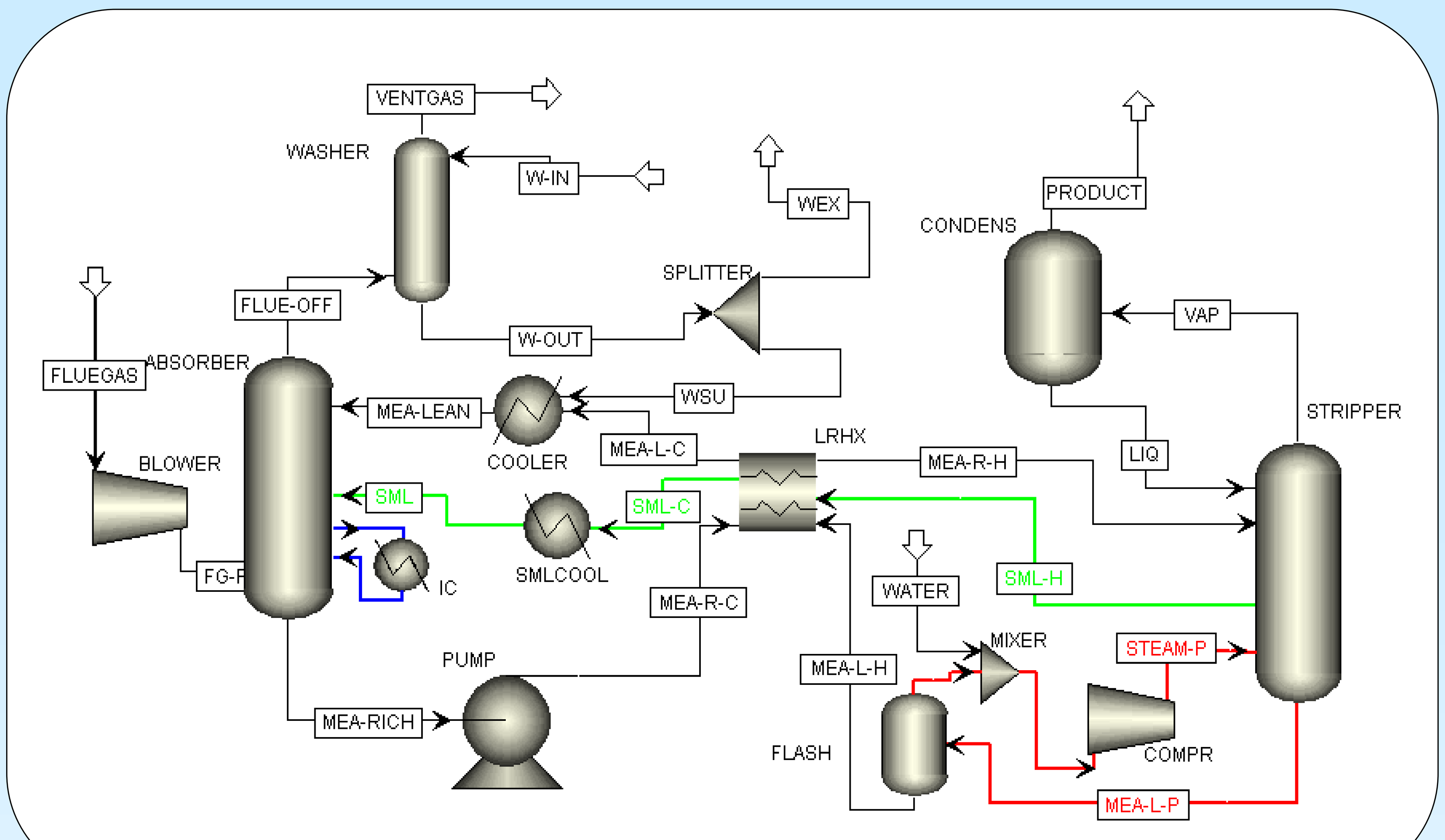

Figure 2: Flowsheet of the CO_2 capture process with process modifications

Process optimization and modifications

Three parameters have a large influence on the process energy consumption: the **stripper pressure**, the **solvent flow rate** and the **solvent concentration**. Moreover, different process modifications have been tested: **lean vapor compression**, **inter-cooling of an absorber stage** and **split-flow configuration**.

Table 1: Influence of process parameters and flowsheet modifications

Process parameter	**Stripper pressure**	**Solvent flow rate**	**Solvent concentration**
Regeneration energy	-16.9%	-5.4%	-2.8%
Process modification	**Lean vapor compression**	**Absorber inter-cooling**	**Split-flow configuration**
Regeneration energy	-14%	-4%	-4%

Solvent degradation

Solvent make-up cost due to degradation may represent up to 22% of the post-combustion capture OPEX![1] Moreover, degraded solvent may reduce the process efficiency, increase corrosion, induce foaming and fouling in the columns.

In order to study solvent degradation under accelerated conditions, a degradation test rig has been built at the University of Liège.

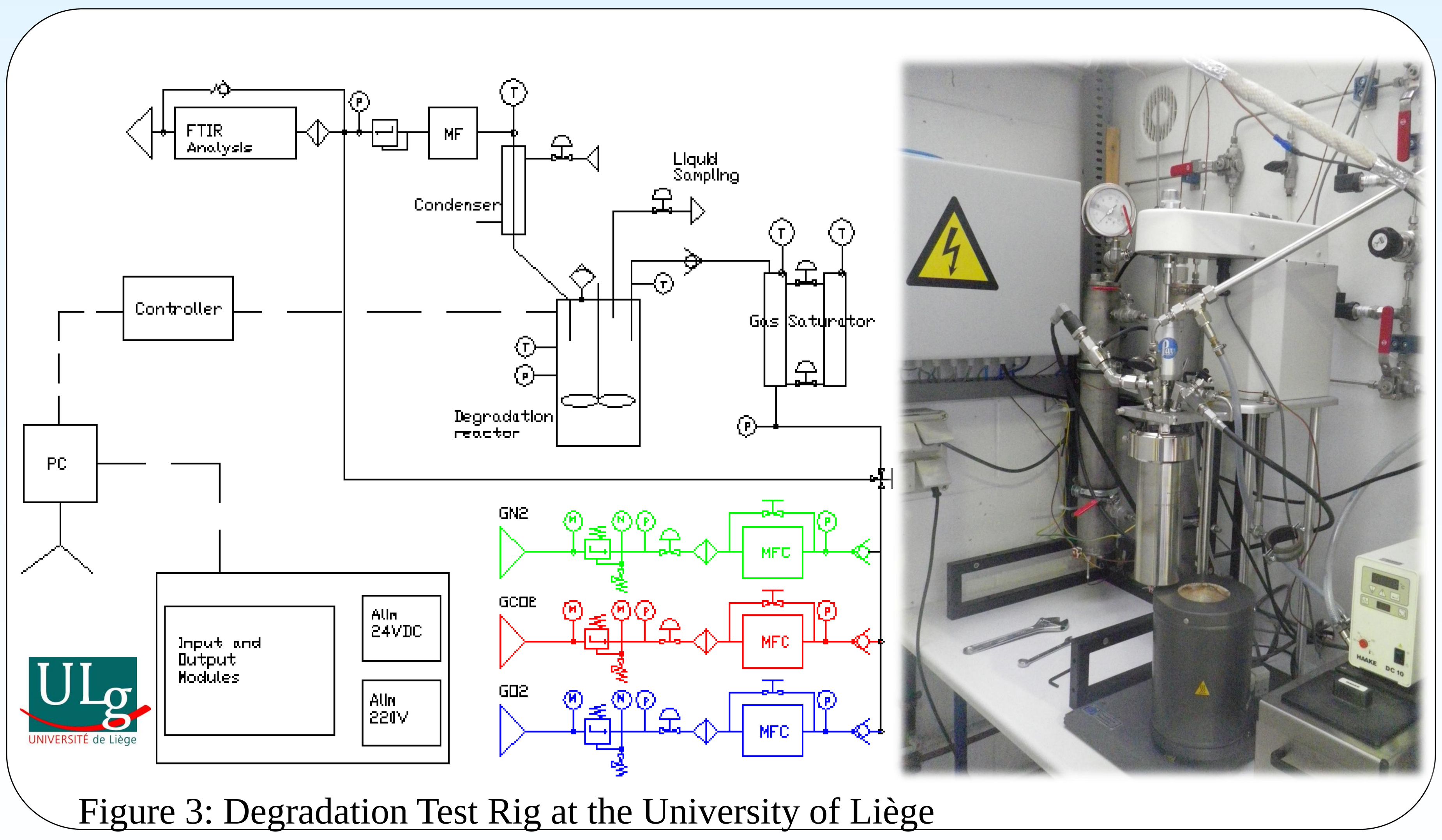

Figure 3: Degradation Test Rig at the University of Liège

The final objective of this PhD thesis is **to make the link between experimental degradation results and simulation work**. A multi-objective optimization of the CO_2 capture process will be performed, considering both degradation and regeneration energy consumption aspects.

[1]: Abu Zahra M., 2009. Carbon dioxide capture from flue gas, PhD Thesis, TU Delft, The Netherlands.

Acknowledgements

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