



MODELING POST-COMBUSTION CO₂ CAPTURE WITH AMINE SOLVENTS

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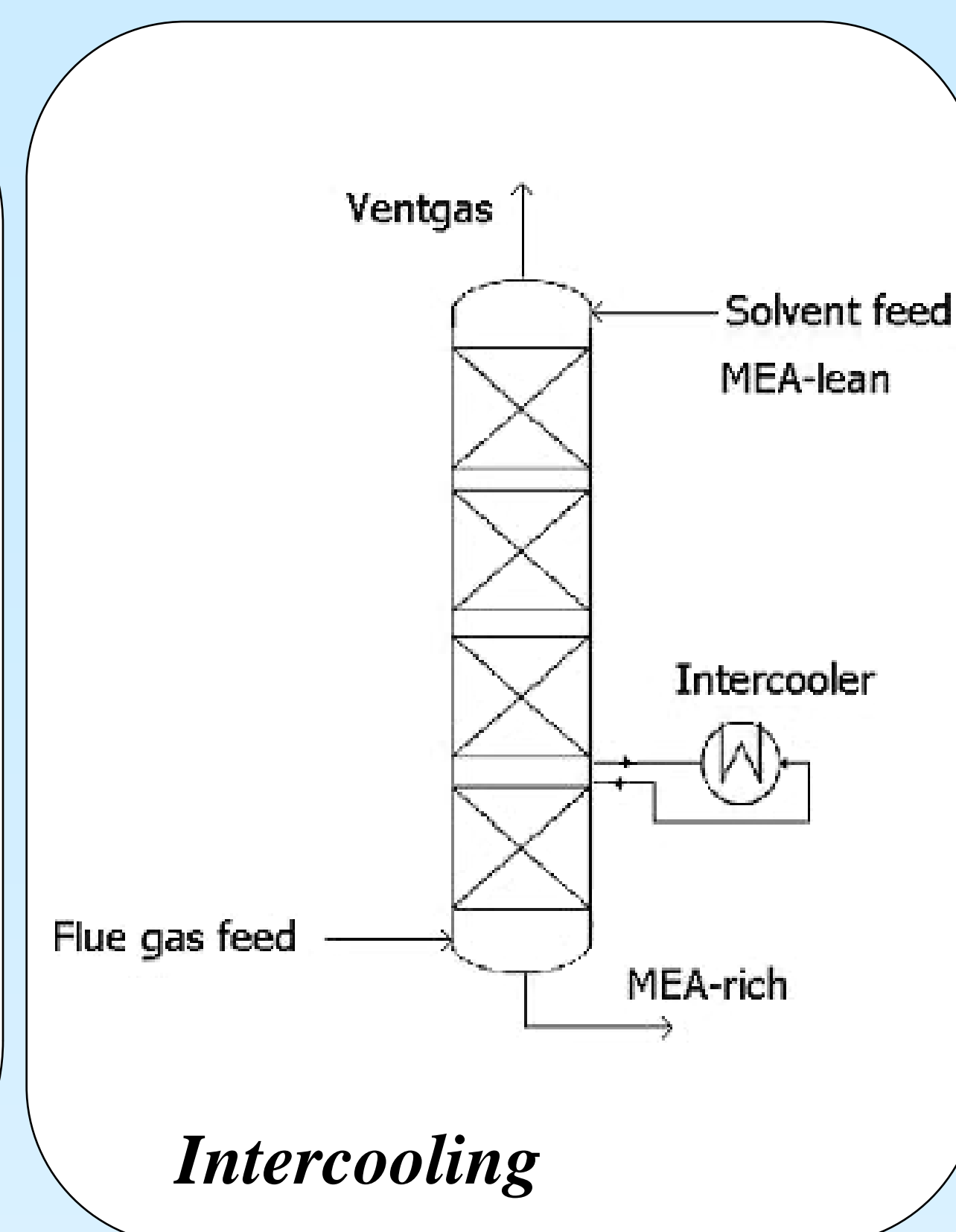
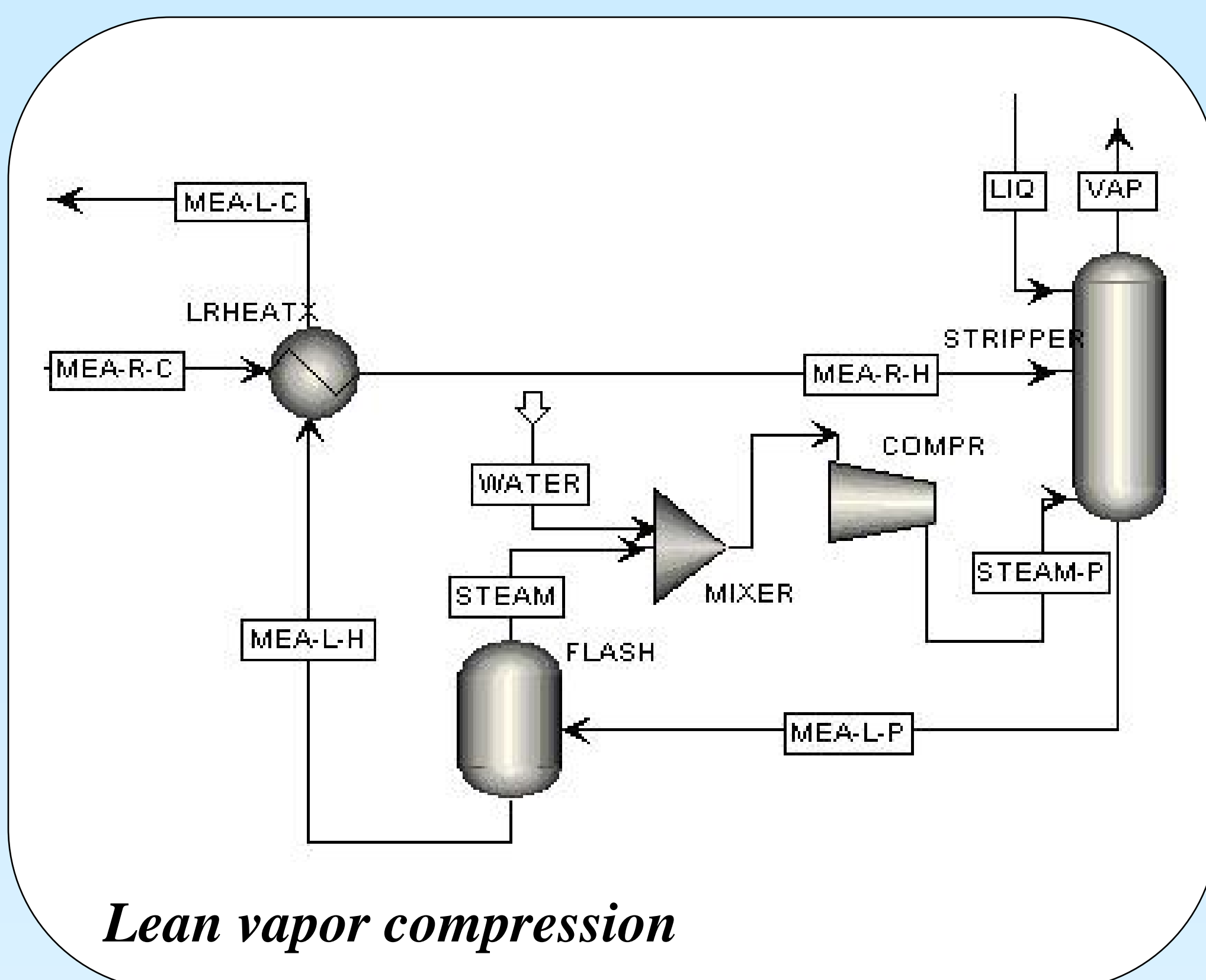
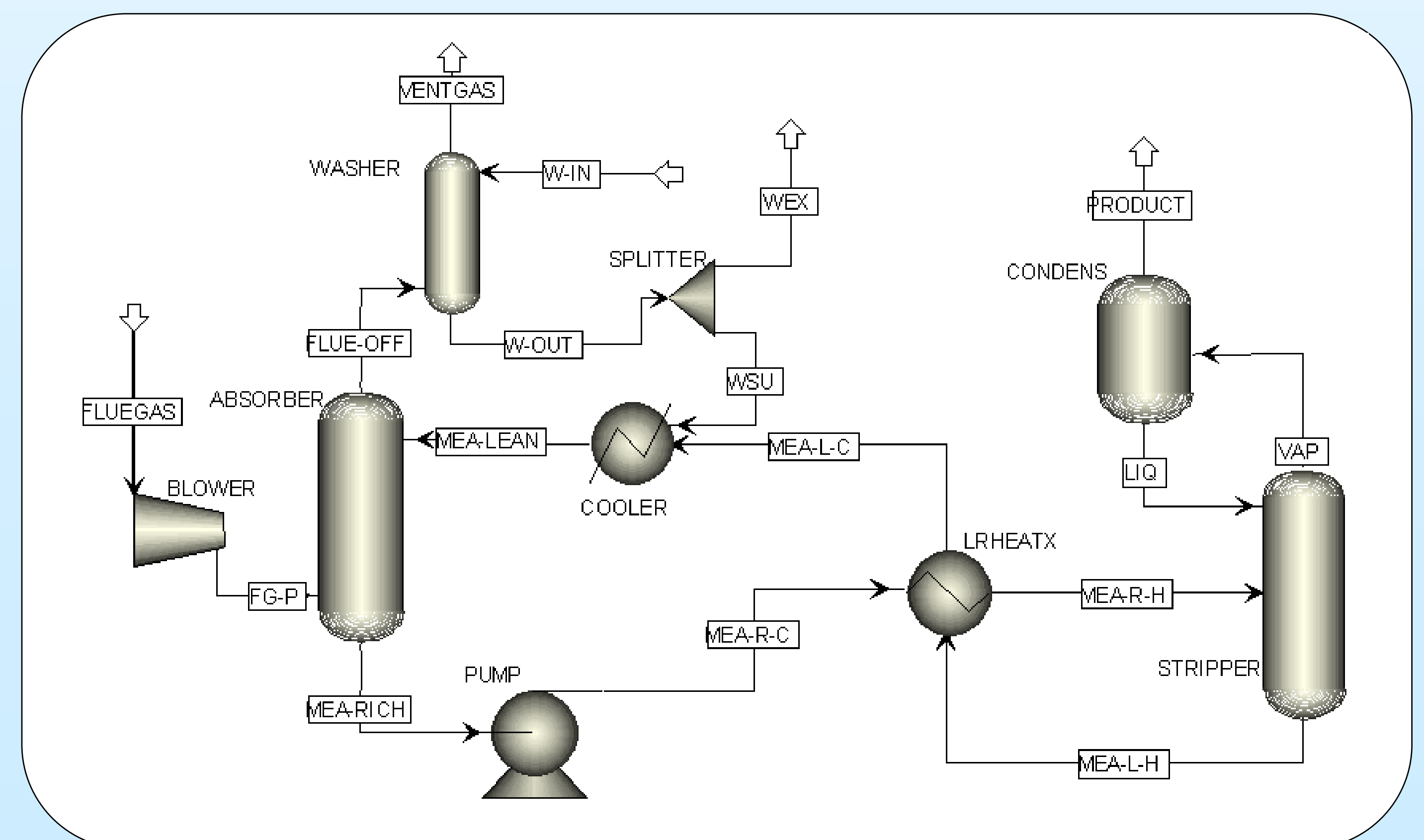
Abstract

In order to avoid the emission of large amounts of greenhouse gas, CO₂ capture in fossil fuel power plants and subsequent underground CO₂ sequestration is studied. The capture occurs by reactive CO₂ absorption into chemical solvent systems at moderate temperature (~50°C) followed by solvent regeneration at higher temperature (~120°C). So far, the most employed solvent for acid gas capture is monoethanolamine (MEA). One main drawback of this technology is the high energy consumption necessary to regenerate the solvent. In the present work, the CO₂ capture process with MEA is modeled using the simulation tool Aspen Plus®. The base case process is optimized and some process improvements are studied that imply a significant decrease of the process exergy consumption.

Model description

The main elements of the flowsheet are the mass transfer columns and the solvent lean-rich heat exchanger. Inside the absorption column, CO₂ is absorbed out of the flue gas into the MEA solvent. In the stripper, thermal energy is supplied to the solvent to release the CO₂ and regenerate the solvent. Between both columns, a heat exchanger performs the heat recovery from the hot regenerated solvent to the cold CO₂-loaded solvent.

Calculations are made using the assumption of a thermo-dynamical equilibrium state on each theoretical plate of the mass transfer columns. This assumption neglects the effects of kinetics and mass transfer limitations inside the columns. This equilibrium-based simulation tool in Aspen Plus® is the Radfrac subroutine and it has been proven to be a very useful tool for the study of the CO₂ absorption process^[1].



Simulation results

Process optimization is performed by varying some clue parameters of the process. The most relevant parameters studied are the solvent mass flow, the solvent concentration, and the pressure in the regeneration column. The thermal energy consumption of the process could be so reduced by up to 16% compared to the base case process.

Furthermore, some process improvements have been tested. On the right, the use of an intercooler between two asorber stages allows a 6%-reduction of the thermal energy consumption if the intercooler is located between bottom stages. On the left, the so-called lean vapor compression configuration^[2] has been implemented. It allows a 18%-reduction of the total exergy consumption for the capture process.

Perspectives

However, the impact of these parameters on the corrosive behaviour of the solvent or on its degradation properties has not been taken into account for the simulation needs. Since solvent make-up costs due to solvent degradation will represent up to 35% of the capture direct operation costs (i.e. 4.78 million Euro per year in the case of a 600MWe bitumous coal-fired power plant^[1]) it has been decided to perform experimental studies to obtain data on solvent degradation rate. Moreover, degradation products are potentially toxic for the environment and this aspect should not be neglected by the design of the capture plant.

The results of the degradation studies will be included into a multi-objective optimization of the CO₂ capture process in order to take into account the possible environmental impacts of the amine solvent degradation and its financial impact on the capture costs. The scheme of the experimental installation for degradation studies is presented on the right.

References

- [1]:Abu Zahra M., 2009. Carbon dioxide capture from flue gas, PhD Thesis, TU Delft
- [2]:Reddy S. et al., 2008. Fluor's Econamine FG PlusSM technology for CO₂ capture. Presentation at Power Plant Air Pollutant Control Symposium, Baltimore

Acknowledgements

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