

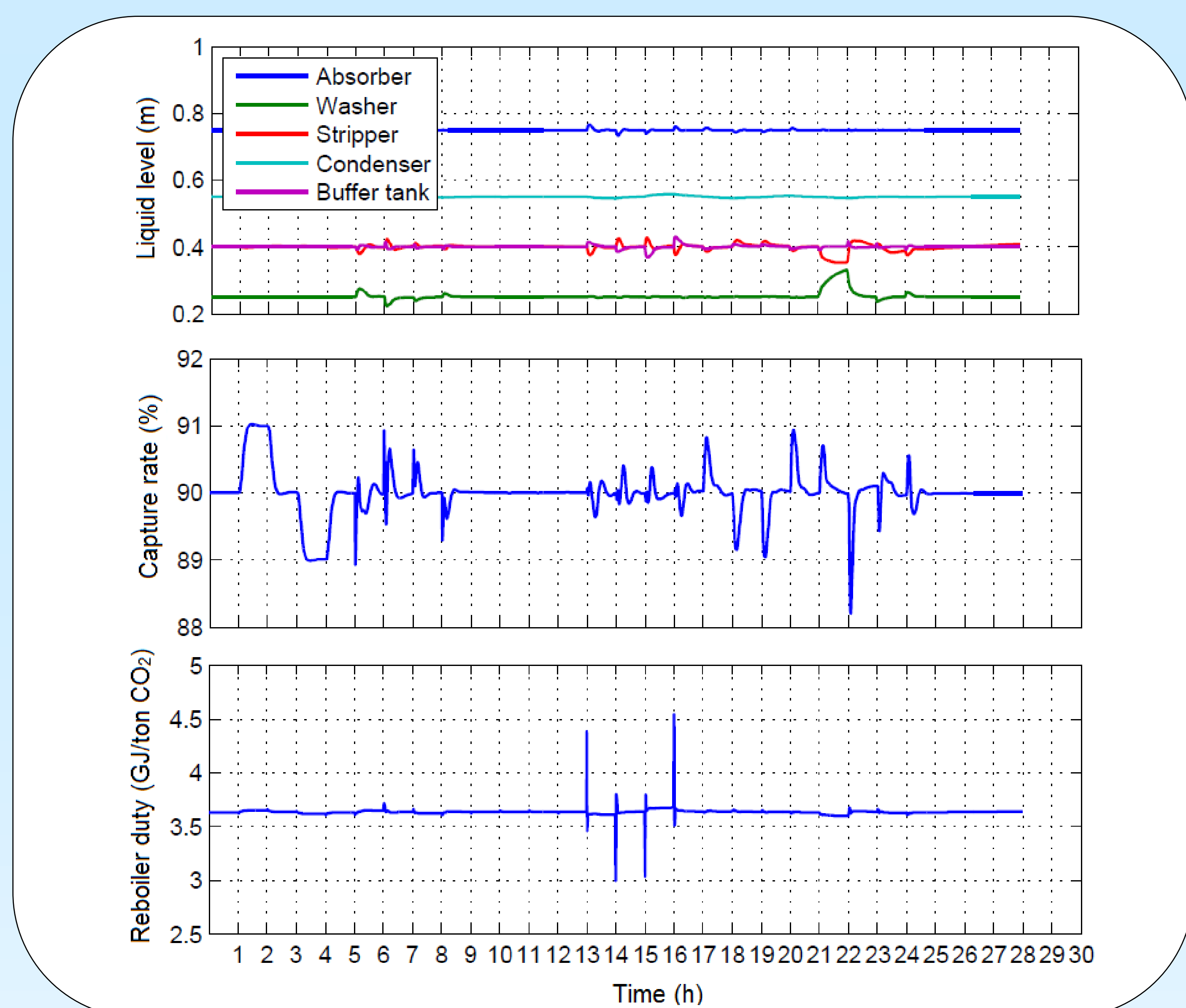
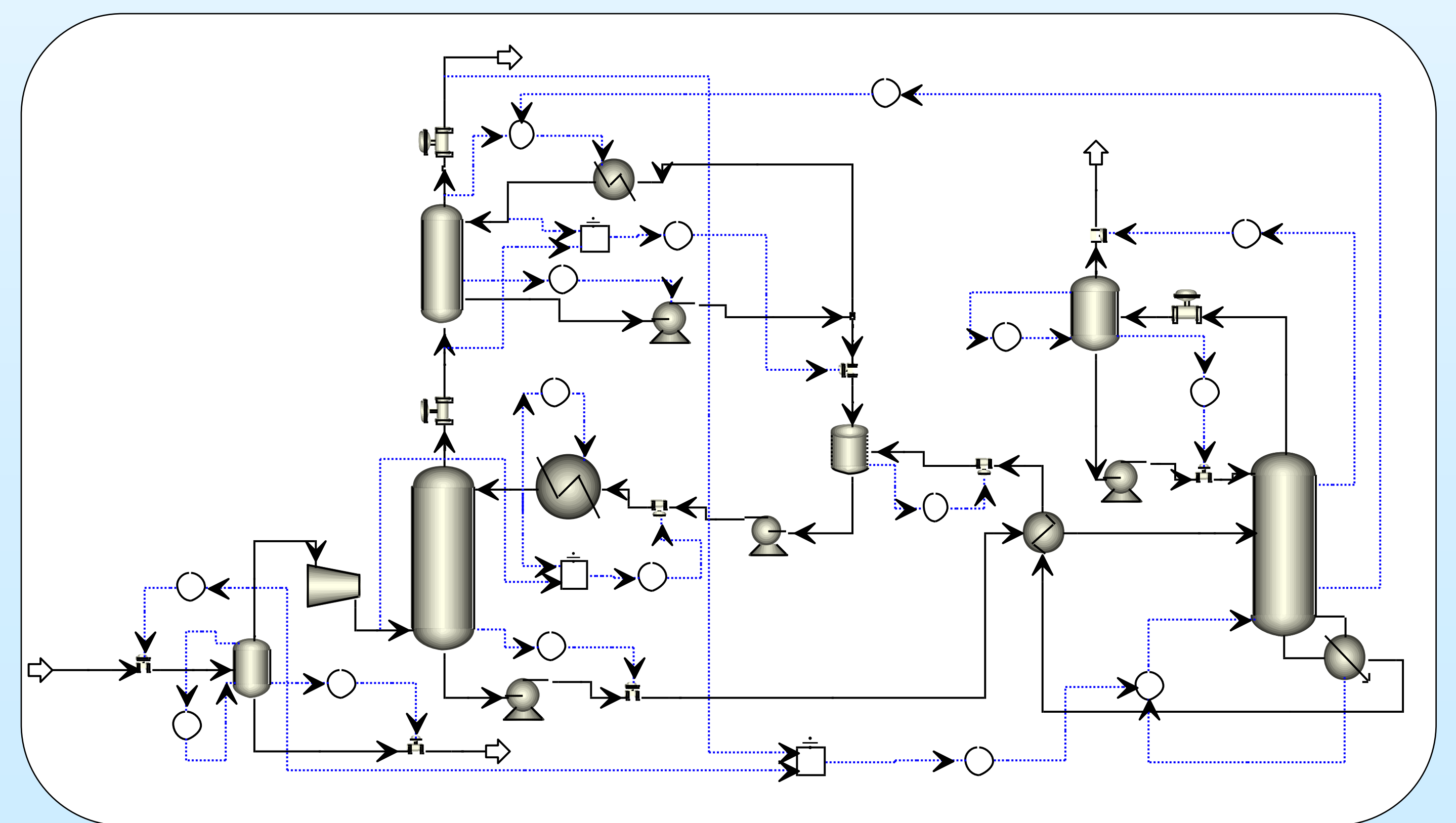
Abstract

The dynamic behavior of a post-combustion CO₂ capture pilot plant is studied using Aspen Plus Dynamics. An innovative process control strategy is tested for regulating the water balance of the process by changing the temperature of the washing water at the absorber outlet. Rejection of disturbances and different load reduction scenarios are applied to evaluate the efficiency of this strategy. Potential operational problems of are identified and solved.

Model description

Thirteen degrees of freedom and thirteen constraints have been identified in the flowsheet. The pairing is the following:

- Sump liquid levels are controlled by valves. Absorber and washer liquid to gas ratios are controlled by varying liquid flow rates.
- Temperatures of the flue gas pre-cooler, the condenser and the solvent flow at the absorber inlet are fixed at 40°C by heat streams, assuming perfect control.
- The stripper pressure is set at 1.7 bar by regulating the outlet CO₂ flow rate.
- The CO₂ capture rate is kept at 90% by varying the reboiler heat duty.
- The stripper sump level reflects the process water balance. The regulation is achieved by varying the washing water temperature at the washer entrance.



Evaluation of the control strategy

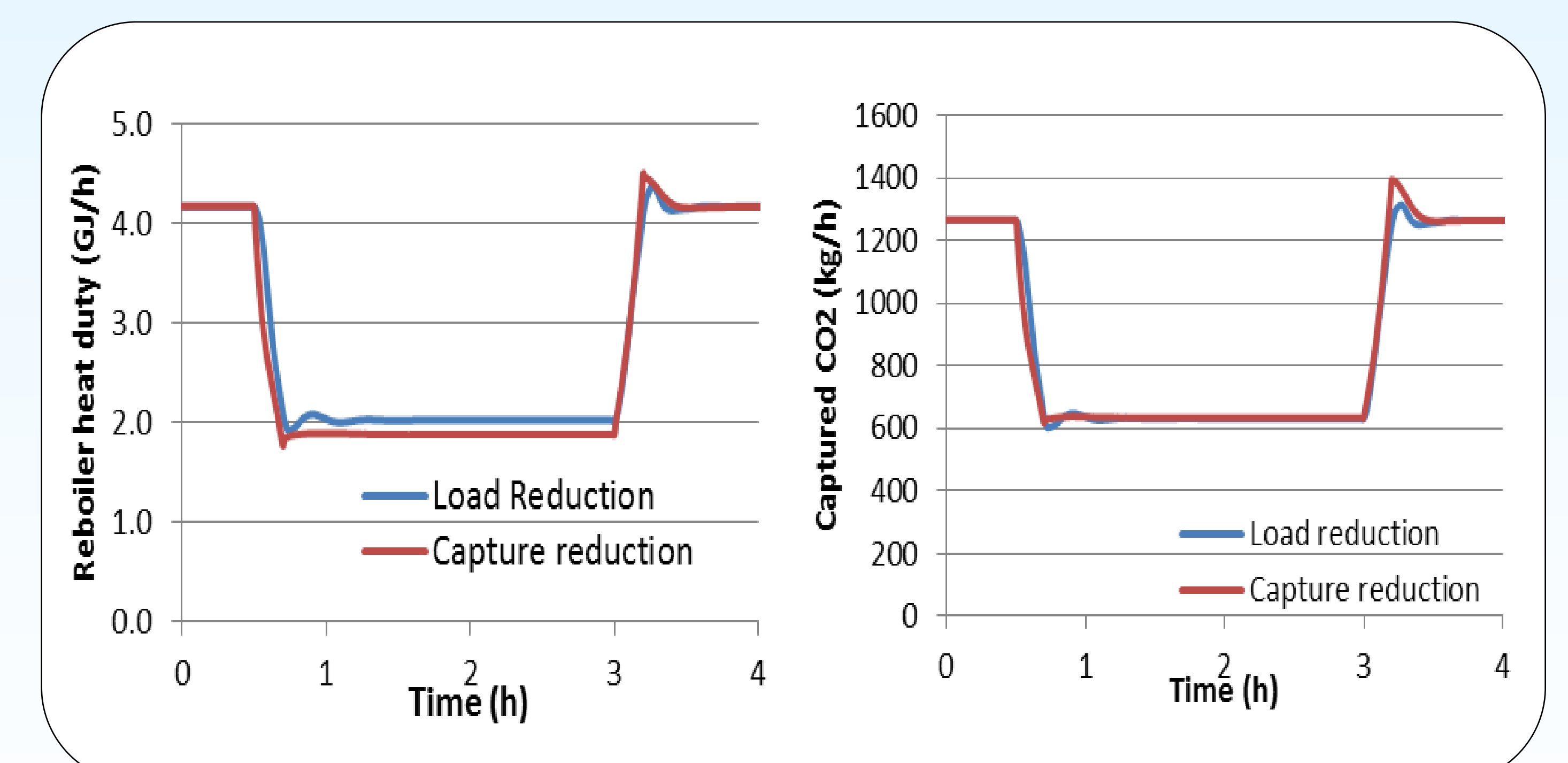
The efficiency of this control strategy is evaluated by simulating small process disturbances. Several set-point changes are successively applied each hour to the controlled variables listed below. The good regulation of sump liquid levels, capture rate and reboiler duty proves the efficiency of the control strategy. Only at t=21h, the washing water pump could not cope with the increased L/G in the washer, leading to liquid accumulation in the washer and to a decrease of the stripper liquid level. The problem can be solved by using a more powerful pump in the washing water loop.

Process variable	Set-point	Disturbance
Capture rate	90%	± 1%
Solvent temperature at the absorber inlet	40°C	± 3°C
CO ₂ condenser temperature	40°C	± 3°C
Stripper pressure	1.7 bar	± 0.1 bar
L/G ratio in the absorber	4.1 kg/kg	± 0.2
L/G ratio in the washer	4.1 kg/kg	± 0.2

Capture flexibility

The electricity production of the power plant can be temporarily increased by reducing the CO₂ capture rate, and thus the steam consumption of the amine solvent regeneration. Two scenarios are compared: a reduction of the capture rate at constant flue gas and solvent flow rates, and a reduction of the treated flue gas load by venting a part of the flue gas to the atmosphere before the absorber.

For a 50% reduction of the flow rate of captured CO₂ within 12 minutes, the reduction of the capture set-point leads to a lower reboiler duty (1.89 GJ/h compared to 2.03 GJ/h) at equivalent CO₂ capture rate. However, operational problems may appear when reducing the capture rate down to 10% within short time scales. They are due to the sudden modifications of the operating conditions. Using the dynamic model, possible solutions are proposed to improve the flexibility of the CO₂ capture plant.



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