Study for Automatic Control Logic for Supercritical CO_2 Cycle

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Introduction

▣ A supercritical CO_2 (S-CO_2) cycle is a compact and efficient power conversion system, and researchers from a wide range of application, including gas turbine, fossil fuel and nuclear, are paying attention

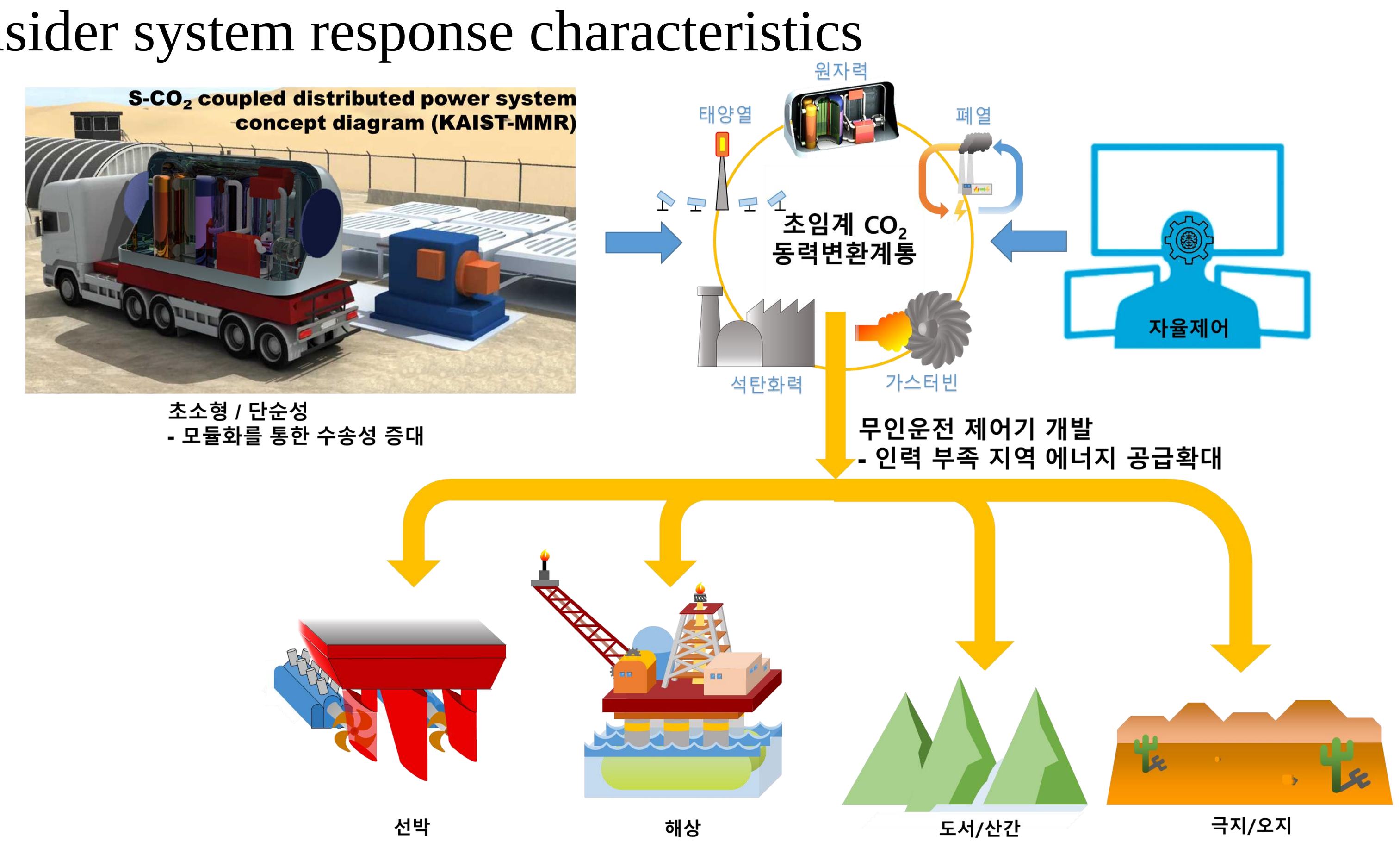
▣ In a critical state, a fluid has gas-like small viscosity, but has liquid-like relatively large density. Especially, the reduced compression work near the critical point facilitates compression process with minimized power consumption

▣ Nowadays, the expansion of renewable energy expedites the decentralization of power system

▣ A distributed power system can serve as an independent power source in electrically isolated region. The key feature of the system is a load following capability

▣ The S-CO_2 power cycle is expected to be able to operate as a distributed power source because the system has simple layout and high power density.

▣ The S-CO_2 power cycle shows different performance according to controller position, gain, and input speed. Thus, it is necessary to consider system response characteristics



▲ *possible application of S-CO_2 power cycle with autonomous control*

Experiment Facility

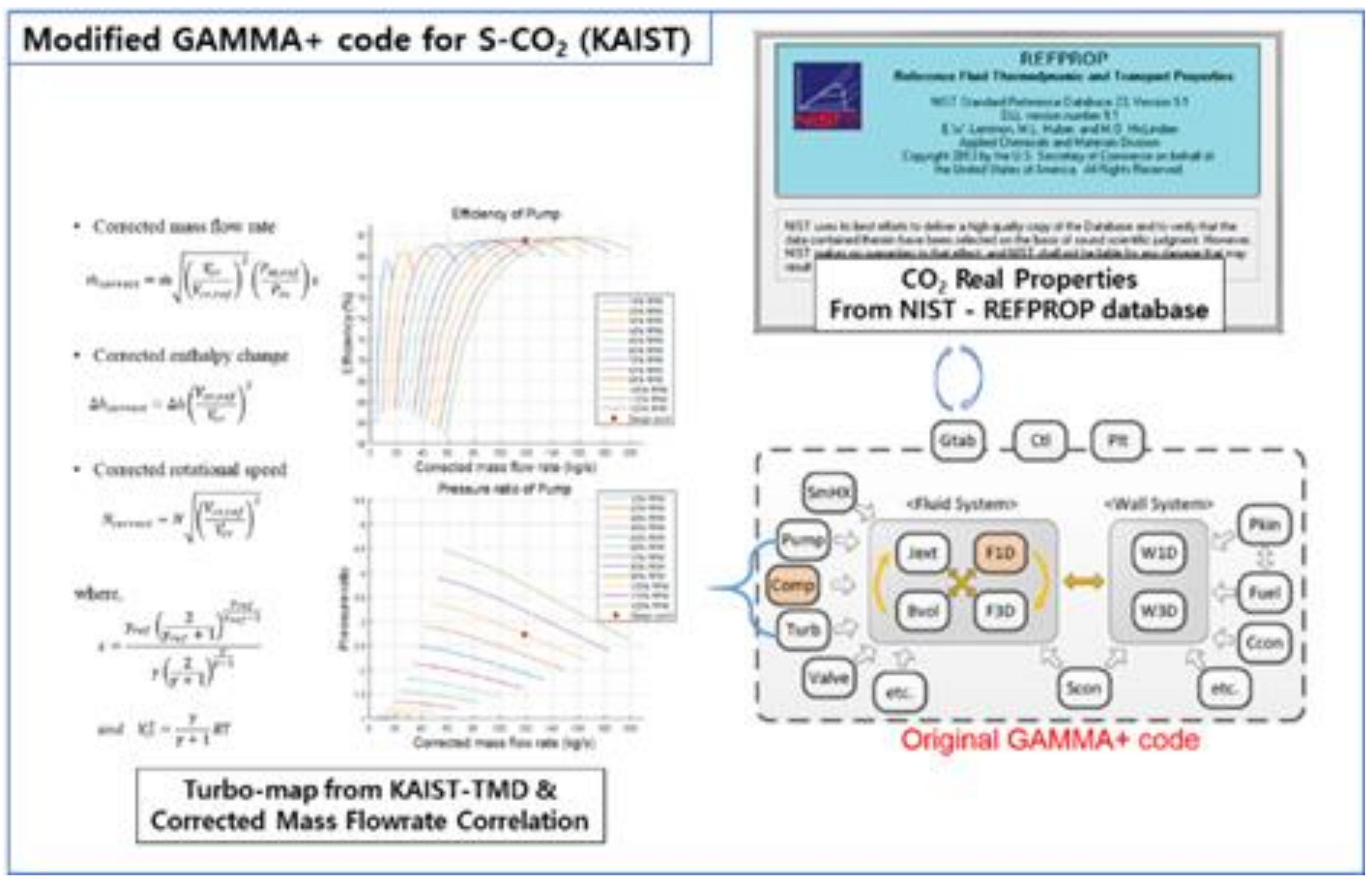
▲ *Bird view of S-CO_2 compression test loop*

▣ Currently, the study for dynamic characteristics of the S-CO2 system is at an early stage. Most of the studies have been conducted through analysis, but it is crucial to demonstrate control logics with experiment loop

▣ The test loop consists of TAC (Turbine-Alternator-Compressor), heat exchanger, chiller, and two automatic flow control valve

▣ In this experiment, it is intended to maintain mass flow rate by changing valve opening fraction. Valve opening fraction can be manipulated between 0-100% by 1%. PID control logic was implemented

Analysis Tool

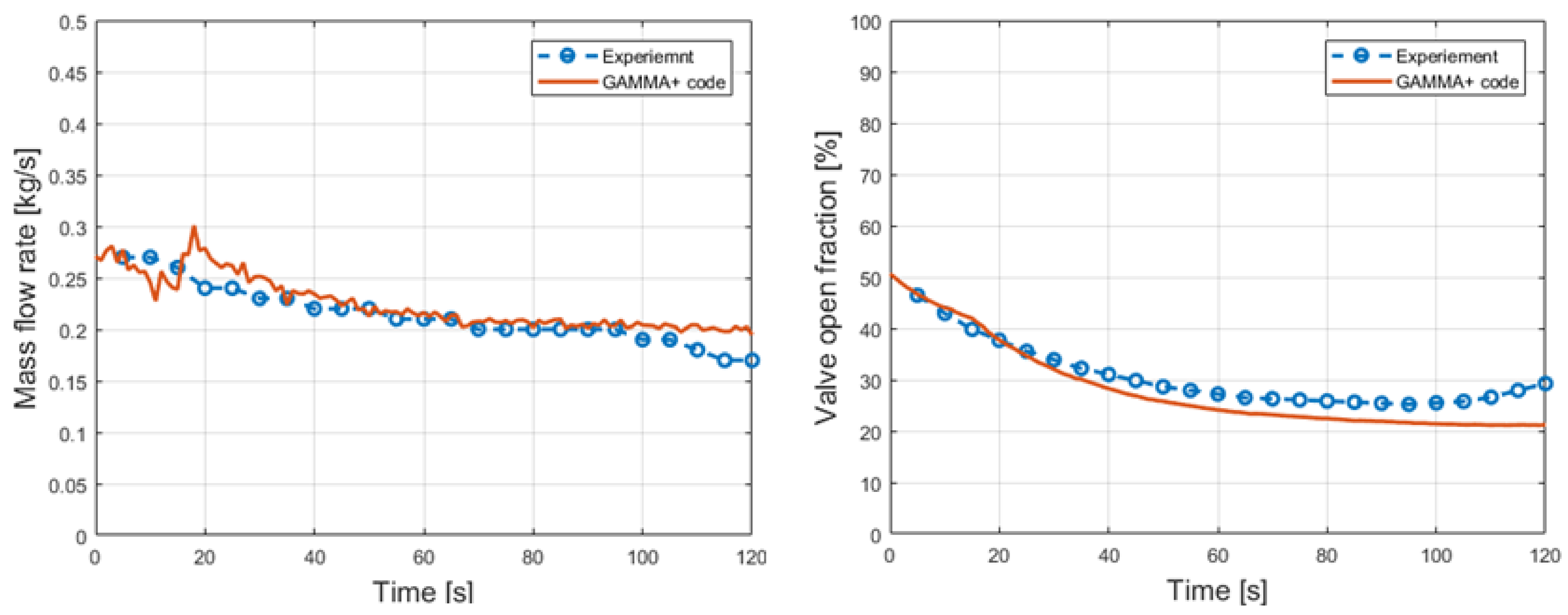


▣ Experiment results was compared with GAMMA+ code

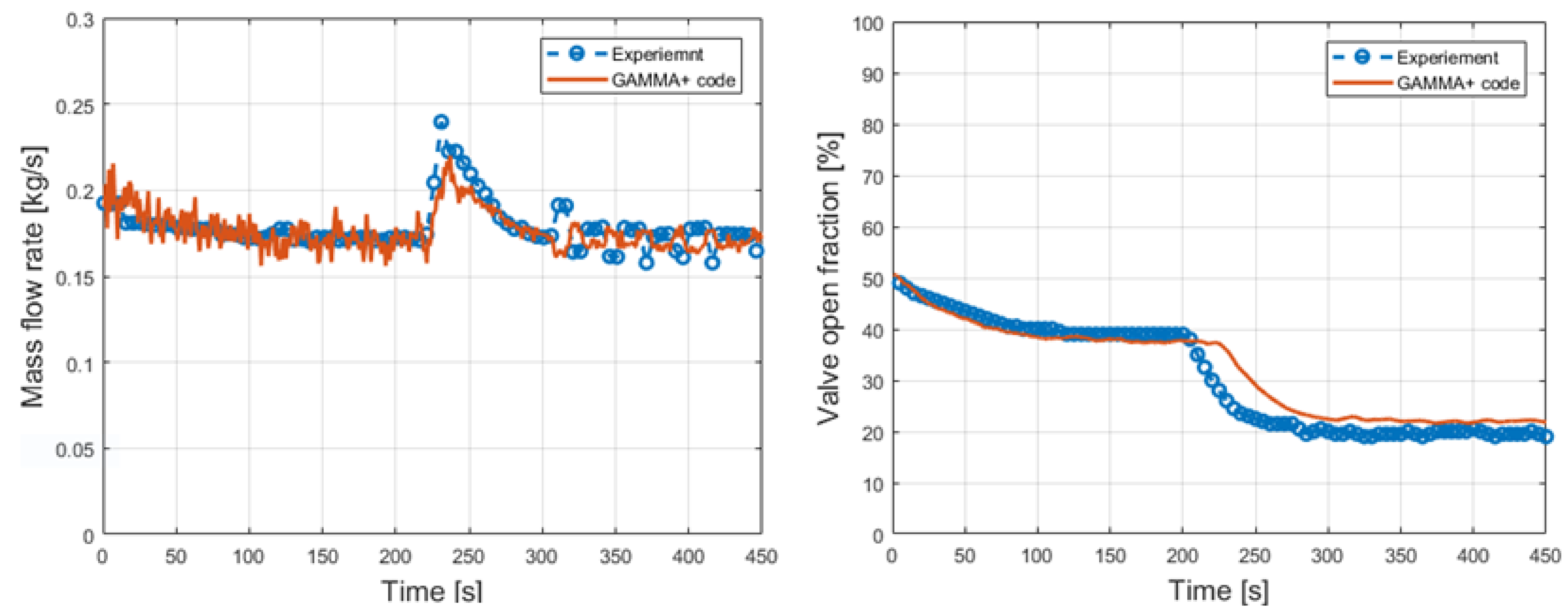
▣ GAMMA+ code was developed for accidents analysis of high temperature gas-cooled reactor originally in KAERI

▣ Later, the code was modified to analyze the performance and dynamic characteristic of S-CO_2 system in KAIST research team

Results and Discussion



▲ *Mass flow rate and valve opening fraction (Test 1)*



▲ *Mass flow rate and valve opening fraction (Test 2)*

▣ The experiment was conducted at 20°C, 50bar condition

▣ Considering valve operating speed, new valve opening fraction was given every five second

▣ Two experiment cases were carried out. In test 1, the mass flow rate was 0.27kg/s at first, but when automatic control was activated, the system was controlled to achieve and maintain the mass flow rate of 0.2kg/s

▣ In test 2, compressor rotational speed was changed from 10,000 to 13,000 rpm at 220s. As a result, the mass flow rate was raised abruptly, but soon it was stabilized to 0.17kg/s because of valve opening fraction change

▣ Additionally, the test results were compared with the analysis results by GAMMA+

▣ Provided that the code and experiment results present good agreements, it can be possible to simulate the control logic and dynamic response of CO_2 system