of 700 °C/35 MP, the connected cycle power generation efficiency of large SCO2 coal fired power plants is 51.82 %, which is significantly higher than that of available supercritical water-steam Rankine cycle power plants. Li et al. [23] analyzed the safety of UTOP accidents in lead-cooled fast reactors coupled with the SCO2 cycle and proposed two UTOP accident mitigation schemes based on the SCO2 cycle.

Furthermore, control strategies were proposed or checked for other conditions, such as Vamshi and Timothy [24] compared different control strategies for low load. Park et al. [25] researched the power swing with valve control method to check SCO2 system load following capacity. Wang et al. [26] investigated the control strategy for start-up and shutdown of the SCO2 recompression Brayton cycle. Fuel supply should match the compressor speed control during start-up or shutdown process.

Summarizing previous researches, it is found that although different control strategies for SCO2 cycle were proposed and applicated for different operation processes, control effect were different. On the one side, the SCO2 systems were different for different researchers, on the other side, the basic dynamic characteristics of SCO2 cycle is unclear. Therefore, some researchers pay attention to the dynamic characteristics of systems or devices. Carstens [14] found that the fluctuation of temperature and pressure at precooler outlet and high temperature heater have great effect on system operation efficiency and the system response speed. Singh et al. [27] investigated the disturbance of environment temperature and solar energy input on concentrating solar power plant with SCO2 cycle, the effect of environment temperature on precooler can affect system performance a lot. Olumayegun and Wang [28] built a dynamic model of SCO2 cycle for industrial waste gas utilization. The fluctuation of waste gas mass flow rate and temperature were found have great effect on dynamic character of SCO2 cycle. Hu et al. [29] calculated the dynamic response characteristic of the recuperator when system power ratio gradually decreased from 100 % to 50 %. There was an intersection between the hot/cold fluid temperature curves under different generation loads. Deng et al. [30] developed a dynamic model of the SCO2 recompression Brayton cycle and examined the effects of high-temperature and low-temperature recuperator on the dynamic characteristics of the cycle.

The dynamic character is very important for the system control strategy development and safety operation of SCO2 Brayton cycle. The complex mutual effect of multi facilities and closed loop iteration of operation parameters makes the system control difficult, more important is that the iteration of pressure and temperature in closed SCO2 cycle were still not clear. In this paper, the dynamic characters of SCO2 cycle and the related facilities were investigated with different turbine back pressure modes, such as normal operation mode (unconfined back pressure), fixed pressure mode and open loop mode. It aims to reveal the interaction characteristic and restrictive relation of SCO2 cycle, which is meaningful to the development of system control strategy and control parameters.

2. SCO2 cycle system and the simulation model

2.1. SCO2 cycle system

In this paper, an optimized recompression SCO2 cycle configuration is designed for the Fluoride-salt-cooled High-temperature Reactor(FHR), as shown in Fig. 1. FLiBe is used as the coolant for the FHR, and FLiNaK is used in the intermediate loop for heat exchange with the SCO2 Brayton cycle system. These two types of molten salt have high boiling point temperature and low flow viscosity at atmospheric pressure, which can fit the FHR operation requirement. Considering the long-term stable operating temperature of metallic materials, the reactor outlet temperature is set as 700 °C. Moreover, considering molten salt liquidity and lower thermal stresses of Hastelloy, the inlet temperature of the reactor is set as 600 °C [31,32]. For the heat transfer in FHR, the heat exchanger end difference between FLiBe and FLiNaK is set as 20 °C, and it is 30 °C between FLiNaK and SCO2. As a result, the temperature of heat source can reach to 700 °C, and the maximum operation temperature for SCO2 Brayton cycle system is 650 °C. Other key parameters of SCO2 cycle are listed in Table 1. However, this paper mainly focuses on the dynamic character of SCO2 cycle, the dynamic character of fluoride reactor and the interaction effect between SCO2 cycle and fluoride reactor is not considered at present research.

2.2. Simulation model for SCO2 cycle

1) Compressor model

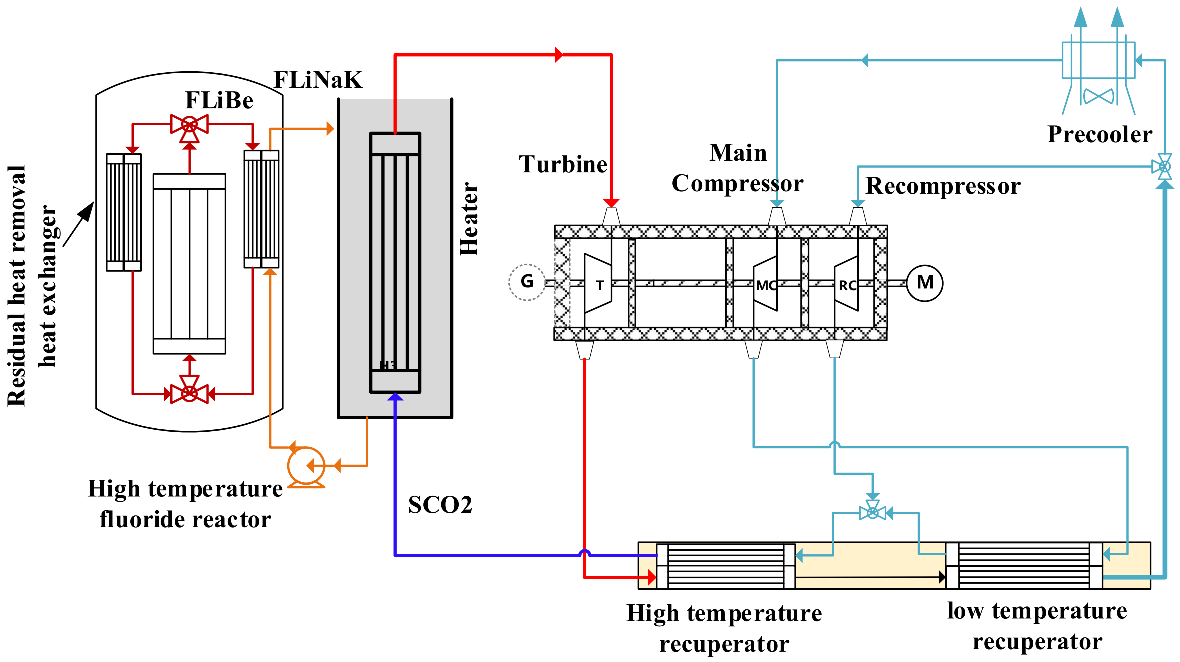

Fig. 1. The designed configuration of SCO2 cycle for fluoride reactor.