Profile SFR-8

TSBS

CHINA

GENERAL INFORMATION

NAME OF THE FACILITY	TSBS
ACRONYM	Thermal hydraulic loops for Single-phase and Boiling two-phase sodium
COOLANT(S) OF THE FACILITY	Liquid sodium
LOCATION (address):	No.28, Xianning West Road, Xi'an, Shaanxi, 710049, P.R. China
OPERATOR	Xi'an Jiaotong University, China
CONTACT PERSON (name, address, institute, function, telephone, email):	Name: Suizheng Qiu Address: No.28, Xianning West Road, Xi'an, Shaanxi, 710049, P.R. China Institute: School of Nuclear Science and Technology, Xi'an Jiaotong University Function: Head of nuclear thermal-hydraulic and nuclear safety group in School of Nuclear Science and Technology, Xi'an Jiaotong University Telephone: +86-13152410318 email: szqiu@mail.xjtu.edu.cn
STATUS OF THE FACILITY	In operation
Start of operation (date):	2010

MAIN RESEARCH FIELD(S)

- ☐ Zero power facility for V&V and licensing purposes
- ☐ Design Basis Accidents (DBA) and Design Extended Conditions (DEC)
- ☒ Thermal-hydraulics
- ☐ Coolant chemistry
- ☒ Materials
- ☐ Systems and components
- ☐ Instrumentation & ISI&R

TECHNICAL DESCRIPTION

Description of the facility

There are two sodium loops and related auxiliary systems in the laboratory.

1. Single-phase sodium loop(Fig. 1, Fig. 3)

The sodium single-phase flow loop is made of SSL 304. The weight of 500kg sodium is stored in the storage tank with a volume of 1.0 m^3 underground. Before operation, sodium in the storage tank is pressed into the pump tank. When the test loop is in operation, sodium is pumped by the E.M. pump and flows through the E.M. flowmeter, preheater, test section, cooling fin, finally returns back to the pump tank. A vacuum pump and an argon gas bomb connected to the loop respectively are used to control the system pressure. A cold trap is used to purify the sodium so that the oxygen concentration can be kept below 10 ppm. A measuring cylinder is used to calibrate the E.M. flowmeter. The cooling system of the electromagnetic pumps includes oil cooling system and water cooling system.

2. Two-phase boiling sodium loop(Fig. 2, Fig. 4)

The two-phase boiling sodium loop is made of stainless steel Inconel-800H. This kind of stainless steel has excellent performance at high temperature and is compatible with high temperature sodium. The weight of 300 kg sodium is stored in the storage tank with a volume of 0.5 m^3 underground. When the test loop is in operation, sodium is pumped by the electro-magnetic pump (E.M. pump) and flows through the electro-magnetic flowmeter, the shell side of the heat exchanger, preheater, test section, outlet chamber, the tube side of the heat exchanger and finally returns back to the inlet of the E.M. pump. In the shell-and-tube heat exchanger, sodium flowing upward in the shell side is heated by sodium of higher temperature from the test section preliminarily. Then sodium flows through the pre-heater and is heated to a preset temperature for the experiment. In the test section, liquid sodium is heated by the heating pin and two-phase boiling flow occurs. After that, sodium steam is condensed in the outlet chamber. The total volume of the outlet chamber and the vacuum expansion tank is 2.1 m^3, which is large enough to prevent the system from pressure deviation. A vacuum pump and an argon gas bomb connected to the vacuum expansion tank respectively are used to control the system pressure. A cold trap is used to purify the sodium so that the oxygen concentration can be kept below 10 ppm.

Acceptance of radioactive material

No

Scheme/diagram

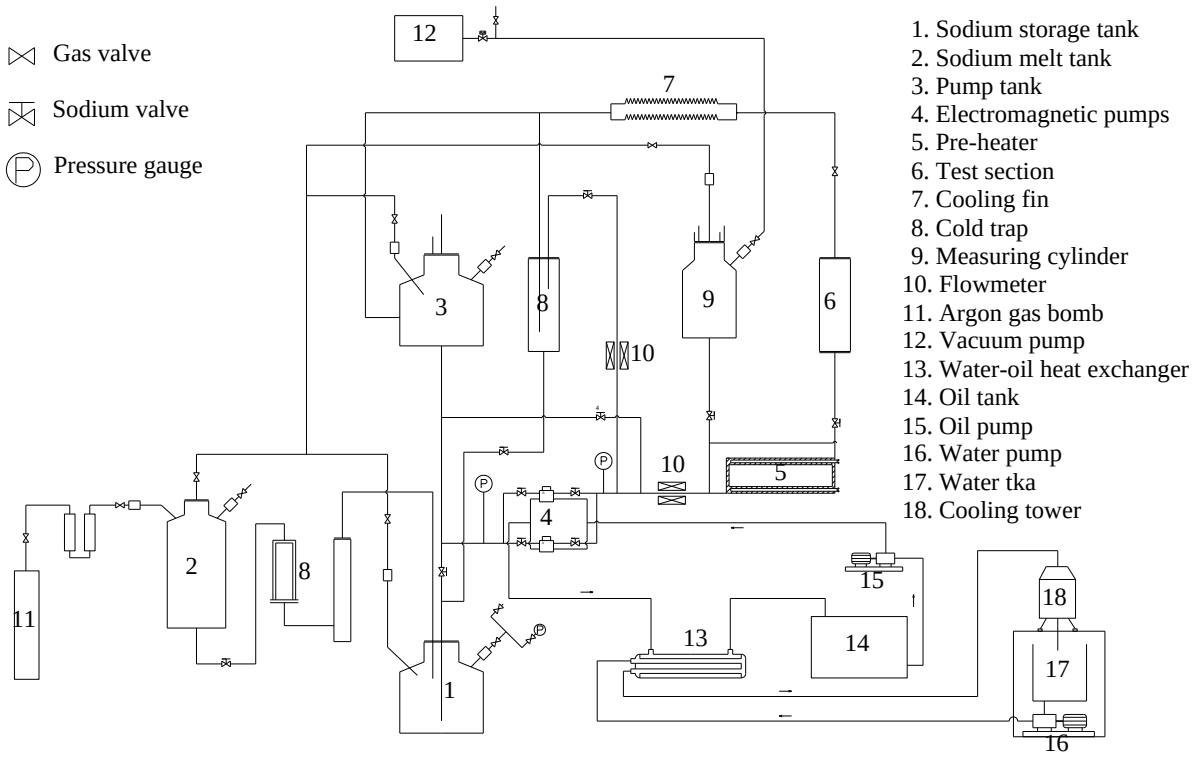

FIG. 1. Schematic diagram of the single-phase sodium loop

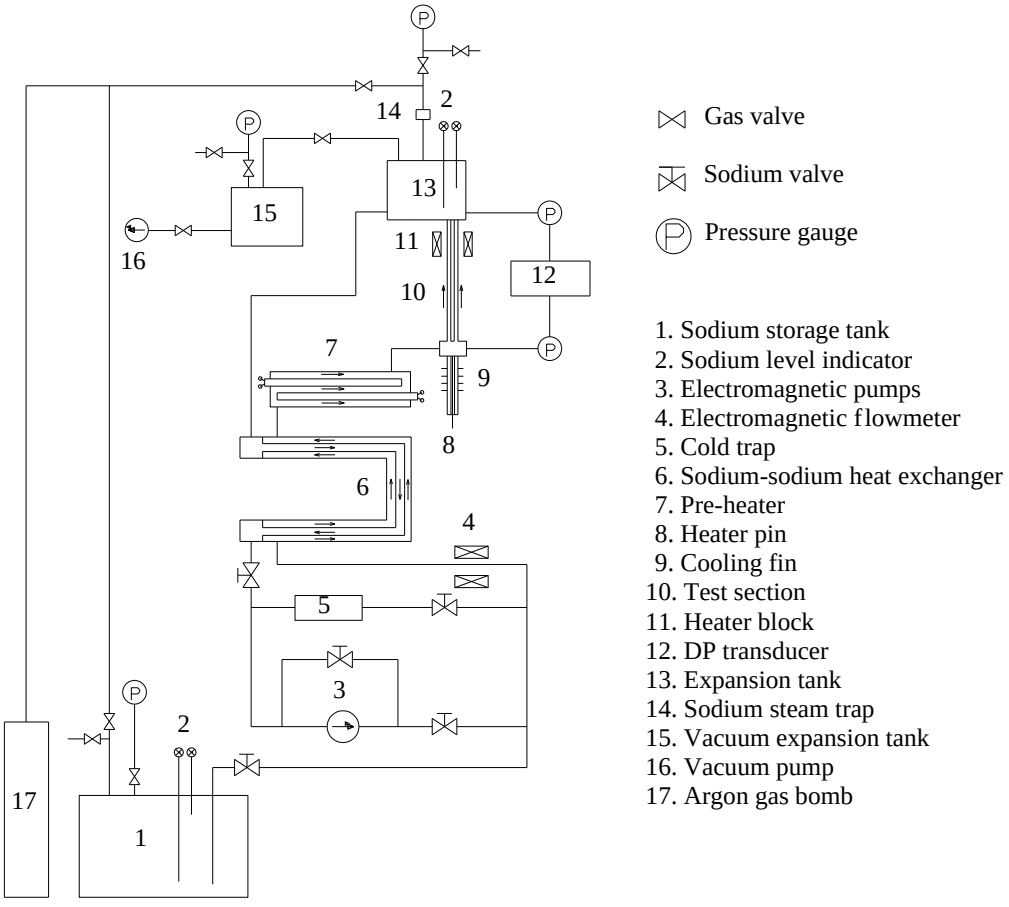

FIG. 2. Schematic diagram of the two-phase boiling sodium loop

3D drawing/photo

FIG. .3. Photo of the single-phase sodium loop

FIG. 4. Photo of the two-phase boiling sodium loop

Parameters table

Table 1 Parameters of the single-phase sodium loop

Coolant inventory	500 kg
Power	Max 170 kW
Test sections	
TS #1	*Characteristic dimensions* Annulus: inside diameter 6 mm, outside diameter 10 mm Overall height →1000 mm
	Static/dynamic experiment Thermal hydraulic(Single phase)
	Temperature range in the test section (Delta T) 200 °C-500 °C
	Operating pressure and design pressure Operating Pressure →0.15 MPa Design pressure →0.6 MPa
	Flow range (mass, velocity, etc.) The maximum sodium flow rate is 10 m^3/h
Coolant chemistry measurement and control (active or not, measured parameters)	There is one cold traps in the circuit to guarantee the sodium purification process on line. The plugging temperature in the meter is lower than 120 °C when the circuit is on operation. The off-line measurement is available and the oxygen content dissolved in the sodium can be used and the limit for this loop is lower than 10ppm.
Instrumentation	Thermocouples, level probes, pressure transducer, Gas purification and injection system, flow meters

Table 2 Parameters of the two-phase boiling sodium loop

Coolant inventory	260 kg
Power	Max 90 kW
Test sections	
TS #1	*Characteristic dimensions* Annulus: inside diameter 6 mm, outside diameter 10 mm Overall height →1000 mm
	Static/dynamic experiment Thermal hydraulic(Boiling two phase)
	Temperature range in the test section (Delta T) 500 °C-1300 °C
	Operating pressure and design pressure Operating Pressure →0.12 MPa Design pressure →0.2 MPa
	Flow range (mass, velocity, etc.) The maximum sodium flow rate is 0.5 m^3/h
Coolant chemistry measurement and control (active or not, measured parameters)	There is one cold traps in the circuit to guarantee the sodium purification process on line. The plugging temperature in the meter is lower than 120 °C when the circuit is on operation. The off-line measurement is available and the oxygen content dissolved in the sodium can be used and the limit for this loop is lower than 10ppm.
Instrumentation	Thermocouples, level probes, pressure transducer, Gas purification and

	injection system, flow meters

COMPLETED EXPERIMENTAL CAMPAIGNS: MAIN RESULTS AND ACHIEVEMENTS

A. Thermal hydraulic characteristics of liquid sodium flowing in annuli with low Peclet number are experimentally studied. Two test sections are used: the inner and outer diameters are 6mm and 10mm respectively for test section No. 1, and 8mm and 12mm for test No.2. Both the two annuli are 1100 mm long. In the experiment, the heat flux ranges from 50 to 210 kW/m^2, Reynolds (Re) number from 0 to 18000 and average fluid temperature from 200 to 500 ^{o}C . Experimental data show that the flow regime of liquid sodium flowing in annuli can be divided into three regions, i.e. laminar flow (Re<2000), transition flow (2000<Re<4000) and turbulent flow (Re>4000). The effects of heat flux, Re number and average fluid temperature on the heat transfer coefficients are investigated separately. Correlations for the friction coefficient and for the Nusselt (Nu) number are obtained based on the experimental data in the three flow regions.
B. Incipient boiling wall superheat of sodium flowing in annulus was experimentally investigated. The annulus was 800 mm in length, 6 mm as inside diameter and 10 mm as outside diameter. The heat flux in the experiment was from 128 to 846 kW/m^2, with inlet subcooling from 63.1 to 287.8 ^{o}C, mass flow rate from 7.2 to 122.0 kg/h and system pressure from 0.85 to 28.79 kPa. The experimental results indicated that the incipient boiling wall superheat increased with the increasing heat flux and inlet subcooling. And lower liquid velocity and system pressure could result in a higher incipient boiling wall superheat. Furthermore, a semi-empirical correlation was obtained from the experimental results. It was also found that the predicting results agreed well with the experimental data.
C. Boiling experiments on sodium flowing through an annulus are performed. The annulus is 1000mm in length, 8mm inner diameter and 12mm outer diameter. The heat flux in the experiment is from 80 to 500 kW/m^2, with inlet subcooling from 63 to 285 ^{o}C, inlet flow velocity from 0.02 to 0.5 m/s and system pressure from 3.67 to 103 kPa. The boiling phenomena, two phase friction pressure drop and boiling heat transfer coefficient are investigated based on the experimental data. Correlations for the two-phase friction multiplier factor ϕ_l^2 and boiling heat transfer coefficient are proposed respectively, predicted results show good agreement with the experimental data.

PLANNED EXPERIMENTS (including time schedule)

An activity of about 4 years is planned in order to investigate the thermal hydraulic characteristics of liquid sodium flowing through bundle. This is a fundamental research for the traveling wave reactor.

TRAINING ACTIVITIES

Training activities can be agreed with Chinese Nuclear Society for the operation of the experimental campaign under the supervision of CNS qualified staff.

REFERENCES (*specification of availability and language*)

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