HELICAL HEAT EXCHANGER FOR APPLICATION IN ENERGY INSTALLATIONS UNDER IRRADIATION

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Introduction. The helical type heat exchanger with LIQUID METAL MELT–OIL–WATER loops has been designed for the operation under radiation conditions at high temperatures up to 450°C and power loads up to 50 kW. The system is equipped with a MHD pump and an induction flowmeter. For continuous maintaining of thermal regime the automatic control system is used. The heat exchanger can be applied for different liquid metals and alloys.

The heat exchanger was designed as one of the units (heat exchanger block or thermostat) for the LiSoR (Liquid Solid Reaction) experimental facility. The heat exchanger (HEX) is the functional unit of the thermostat.

The main goal of LiSoR experiment [1] is the development of a technology and operating regimes of main aggregates for MEGAPIE-SINQ projects (for 1 MW power) at Paul Sherrer Institute (PSI). As a heat transfer medium in the heat exchanger, the eutectic alloy lead-bismuth (LBE) was used. The work of the thermostat has been tested during more than 4000 hours of continuous operation. High efficiency and easy control of the heat exchanger have been demonstrated.

In this report the description and characteristics of HEX in LiSoR experiment [2] are presented in more details.

1. Thermostat. The thermostat has been designed and fabricated in Latvia. The conceptual design and calculations were carried out by UNISEM Ltd, Riga in 2000–2001. The real design and fabrication of all HEX parts were made at the Institute of Physics of University of Latvia (IPUL). Also all necessary technological tests of aggregate have been fulfilled. The experimental version of the heat exchanger was realized as two modules: the first module with LBE-OIL loops and the second module with OIL-WATER loops. Full scale tests of the thermostat were carried out at PSI. The tests of thermostat operation were successful. The thermostat was operated (over 4000 hours) during the time period of 2003 – 2005 on the LiSoR facility applying an irradiation block SINQ.

2. Illustrations and basic performance characteristics. The general view of HEX on the test stand at IPUL is represented in Fig. 1.

The assembly of the LiSoR experimental facility with the thermostat is illustrated in Fig. 2. In front view the module of HEX can be seen.

The calculated characteristics of HEX are demonstrated in Table 1. The experimentally measured characteristics of HEX (flowrate, temperature of LBE) depending on time at irradiation conditions are shown in Fig. 3.

3. Summary. The work at development of the thermostat and its tests in the frame of the LiSoR experimental facility at PSI during the time period of 2002–2005 demonstrated the following:

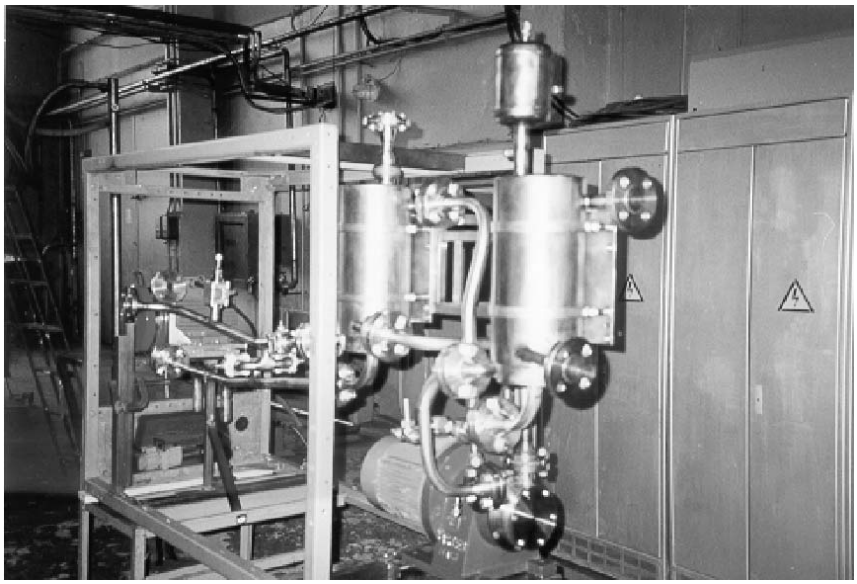

Fig. 1. Heat exchanger for the LiSoR experimental facility on the test stand at IPUL.

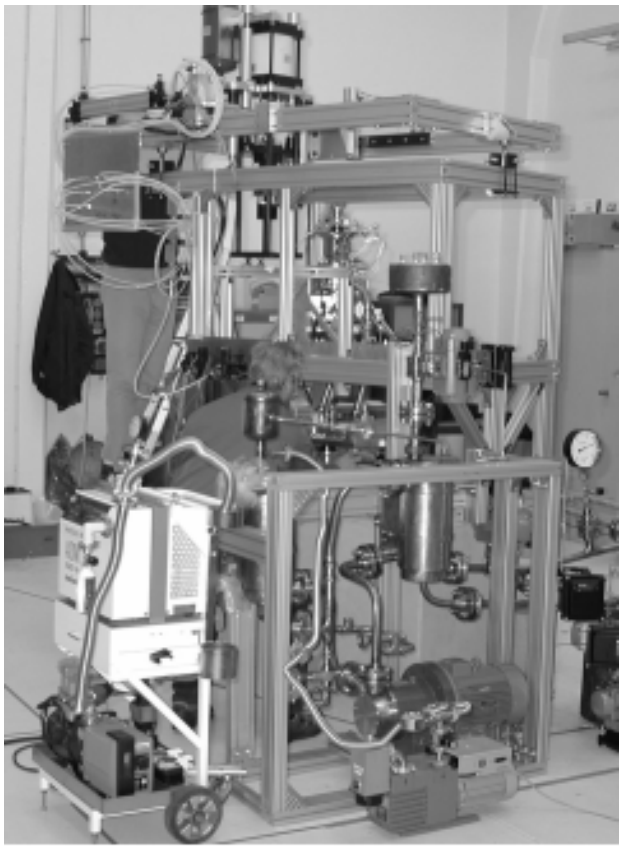

Fig. 2. Module of the LiSoR experimental facility with the thermostat at PSI.

Heat agent	LBE	DIPHYL	DIPHYL	Water
Heat transfer area, m^2	0.17	0.17	0.16	0.16
Flowrate, l/s	0.2	1.6	1.6	1.4
Velocity, m/s	0.56	3.33	3.33	2.92
Pressure losses, bar	0.2	0.34	0.5	0.24
Input temperature, °C	300	140	150	45
Output temperature, °C	200	150	140	50
Heat power, kW	30	30	30	30
Static pressure, bar	0.4	2	2	5

Table 1. Basic characteristics of the thermostat in the LiSoR facility at PSI

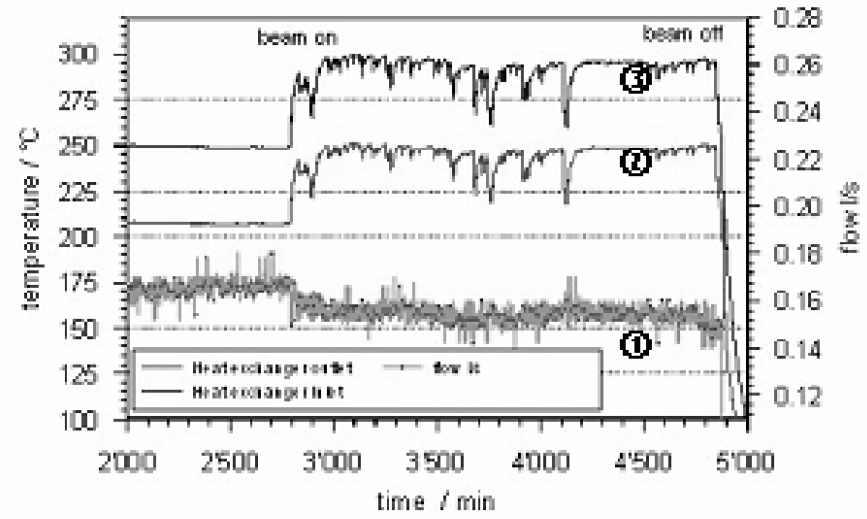

Fig. 3. Measured operation characteristics of the HEX on the LiSoR facility for LBE depending on time: 1. Flowrate, 2. Outlet temperature, 3. Inlet temperature.

- The methods of calculations and the design of a helical type heat exchanger have been developed;
- The prototype of the heat exchanger device having small overall dimensions and high technical and operation characteristics has been fabricated. Two modules having overall dimensions 180*44*340 mm and weight 16.5 kg allow to transfer heat power up to 50 kW;
- The technology of production of the helical heat exchanger is rather simple and there is no need for sophisticated equipment, but at the same time it ensures the needed quality of device;
- The experiments at alternating loads at operating conditions both with and without irradiation have demonstrated a high reliability of the heat exchanger in real conditions;
- The resource of operation of the thermostat exceeded 4000 hours. Technical potentialities of further operation of the helical heat exchanger and thermostat as a whole unit are being considered;
- Good agreement between the calculated operation characteristics of the heat exchanger and the results of its experimental tests is demonstrated;
- The experience gained at development and tests of the thermostat for the LiSoR facility were used at developing of an electromagnetic pumps system (EMPS) for the MEGAPIE project [3];

- Conceptual design of the helical type heat exchanger is considered as a base concept for the following stages of the projects such as MEGAPIE and SINQ projects for powers up to 1 MW (as a version of general block of the heat exchanger and electromagnetic pumps [4]);
- Different modifications of the considered above conceptual design of the helical type heat exchanger seems to be perspective also in other different fields of industrial and energy plants.

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