HEAT EXCHANGER WITH AN ELECTROMAGNETIC PUMP FOR APPLICATION IN ENERGY PLANT INSTALLATIONS

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Introduction. A new conceptual solution for the heat exchanging aggregate LIQUID METAL – OIL – WATER in Accelerator-Driven System is presented. The idea of the concept is combination of a heat exchanger with a MHD-pump in one common unit. The advantage of such solution is its compactness and possibility to use the oil loop simultaneously also as a system for cooling the pump. It is shown that a therm- regulating system with a helical heat exchanger and a built-in MHD-pump has a higher efficiency in comparison with the existing concepts.

Presented materials are the extension and development of the works related to the LiSoR and MEGAPIE projects [1, 2]. The results of investigations have been focused on the next stage of Sthe INQ project. Developed in Latvia the concept of a helical heat exchanger (HEX) with a built-in MHD-pump (EMP) is alternative to the system of heat transfer and melt circulation (lead-bismuth eutectic alloy - LBE) implemented in the MEGAPIE project.

Conceptual design and calculations of the heat exchanger have been carried out by UNISEM ltd, technical design and documentation were performed at the Institute of Physics of University of Latvia (IPUL). The aggregate includes a LBE-OIL loop, OIL-WATER and WATER-WATER loops. The developed version meets all technical requirements of the SINQ project. It is shown that the required characteristics of the heat exchanger for specified overall dimensions and heat power of 1 MW are accessible and reliable.

1. Combining the EMP and HEX in one unit. The annular heat exchanger is installed on the housing of EMP. The draft of the unit block design EMP-HEX is illustrated in Fig. 1.

The thermostat includes concentric modules with helical channels for heat transfer agents. A similar HEX design was developed for the LiSoR facility and demonstrated good efficiency and controllability during long run tests [3]. The block-like construction of EMP-HEX allows to increase the diameter of EMP and the channel for LBE without increasing the overall common dimensions.

The combined EMP-HEX module for the SINQ project permits operation of the aggregate with the motion of LBE into opposite direction (in the MEGAPIE EMP SYSTEM project the change of the LBE flow direction is not foreseen).

The analysis showed a sufficient advantage of the design concept when the hot LBE from the active the BEW zone first is moved into HEX. After it the melt with a lower temperature is pumped through the EMP and injected into the active zone for cooling the BEW and reception of irradiation energy. Such solution cools down the temperature of LBE in the EPM channel from 400°C up to 235°C that, correspondingly, increases the life time and realibility of the EMP.

In order to increase the reliability of the thermostat, parallel connection for the coils groups of the EMP winding is applied. This allows the operation of the

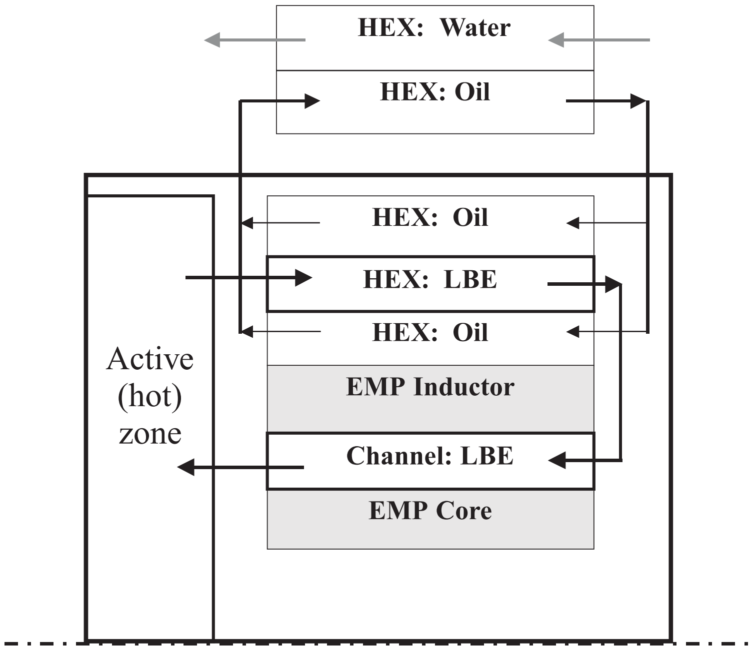

Fig. 1. The scheme of the EMP-HEX block unit.

EMP also in the case when some part of the winding is switched off. Herewith, the load of thte EMP does not exceed the technical limits. The main parameters of the EMP-HEX block unit at nominal and emergency operating regimes are represented in Table 1.

Parameter:	EMP, nominal/ /emergency regime	HEX
Dimensions, mm	∅310 × 110 × 790	∅400 × 40 × 1200
Weight, kg	260	90
Parameters of LBE		
Flowrate, l/s	4	4
Velocity, m/s	1.1	1.0
Input temperature, °C	235	400
Output temperature, °C	235	235
EMP characteristics		
Pressure, bar	1	–
Coil current, A	22/34	–
Phase voltage, V	203/310	–
Active power, kW	22/30	–
Total power, kVA	27/37	–
Max. temperature, °C	290/320	–
OIL circuit		
Flowrate, l/s	–	18.6/20
Velocity, m/s	–	4.7/5

Table 1. Main estimated operation characteristics of the EMP-HEX block with helical design at nominal and emergency regimes for the heat power of 1.0 MW.

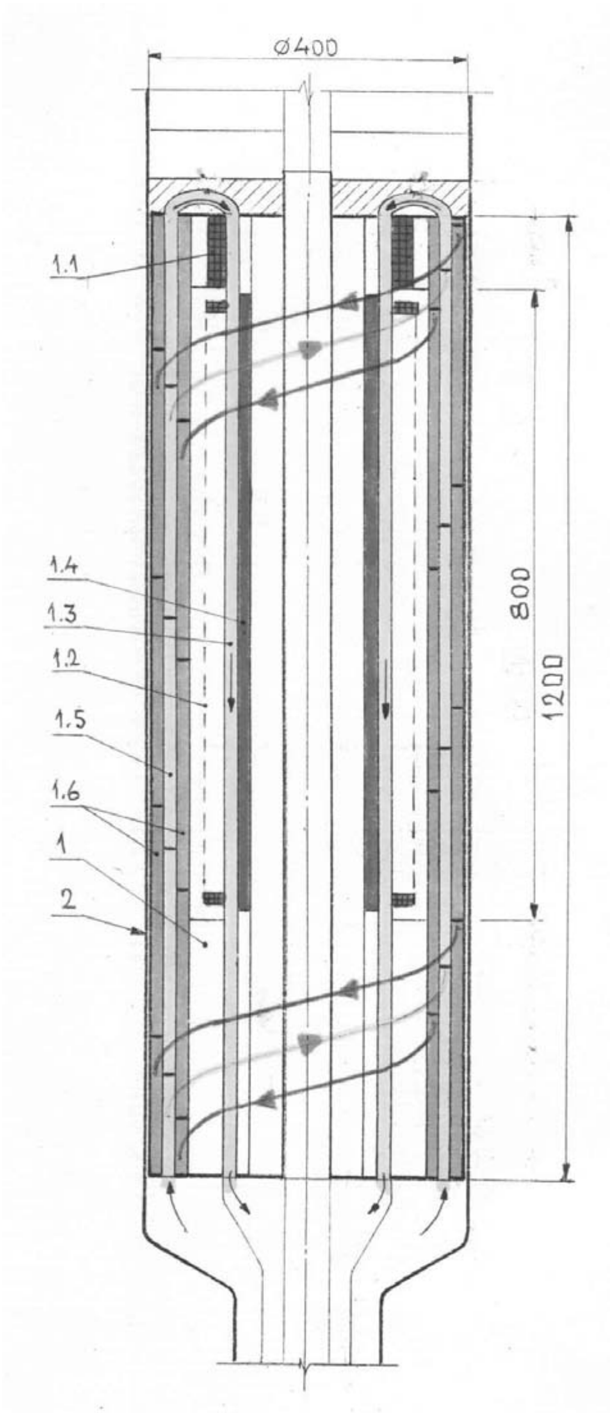

Fig. 2. The sketch of the EMP-HEX block unit with indicated directions of LBE and Oil flows. Notations on the sketch: 1 – zone of the EMP system; 1.1 – EM flow meter; 1.2 – MHD-pump; 1.3 – LBE channel of the EMP; 1.4 – passive core of the EMP; 1.5 – LBE channel of the HEX; 1.6 – Oil channel of the HEX; 2 – housing of the target.

The sketch of the EMP-HEX block unit (helical design) with indication of directions of LBE and OIL flows is presented in Fig. 2.

2. Conclusion. LiSoR experiments and experience gained at design work for the MEGAPIE project demonstrated that a helical type LBE–OIL–WATER heat exchanger has high efficiency and relatively small overall dimensions [4]. A similar HEX may be installed on the outer housing of the EMP. Such solution allows to minimize the overall dimensions of the energy plant, simplifies the construction and lowers the temperature of LBE. The possibility of over nominal operating regime is foreseen (emergency switching off of group of winding coils). At this operation the characteristics of the EMP remains (the pressure developed by the EMP, provided the LBE flowrate) without suffcient change to a worse temperature regime. The mentioned factors show that the suggested conceptual solution of the problem of heat transfer and cooling may be efficiently used in SINQ installation.

The design concept of the combined module EMP-HEX can be reccommended also for other applications in energy plants and industry.

3. Acknowledgments. The authors are grateful to experts of the Laboratory of Physical Hydromechanics (IPUL) and personally to I. Bucenieks and A. Zik for useful discussions and their help in work.

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