Concept of a Heat Pipe Assembly Test for a Heat Pipe Cooled Space Reactor

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1. Introduction

Nuclear is a power source meeting the requirements for the manned space missions on the moon with reasonably small mass. The fission surface power should be simplified to minimize the effort for the maintenance in a space environment. The combination of sterling engine and liquid metal heat pipe is a key for the simplified system [1]. As shown in Figure 1, sterling engines, which are effective power conversion system in terms of payload and maintenance, and bendable heat pipes, which transfer heat from the reactor core to the sterling engines, are applied for Korea Atomic Energy Research Institute's (KAERI) heat pipe cooled reactor considering the space management.

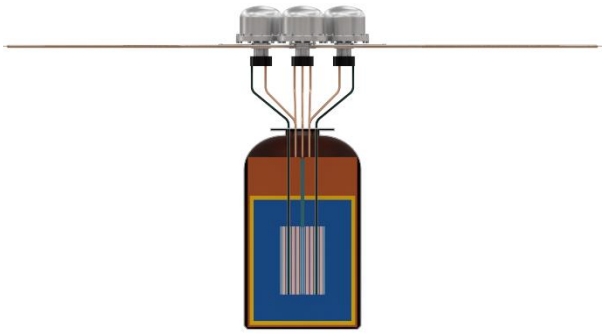

Fig. 1. Concept of KAERI's heat pipe cooled reactor for a fission surface power system.

We developed an approach to introduce a bendable heat pipe with a hybrid wick structure. The system consisted of a braided wire wick and a sintered metal powder wick [2].

Fig. 2. Braided wire wick structure in bendable heat pipes.

We manufactured sodium heat pipes and conducted tests for measuring the operating limit of the straight heat pipes on a target operating temperature [2].

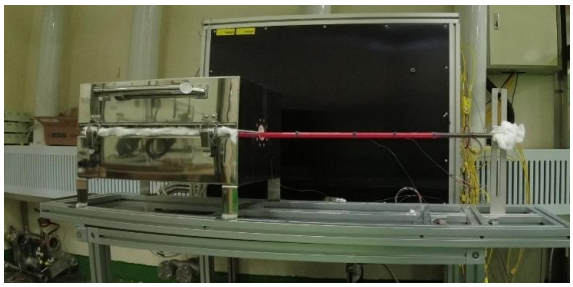

Fig. 3. A sodium heat pipe and test for measuring operating limit of a heat pipe.

Heat pipe analysis code, LUHPIS [3], predicted operating limit of the straight heat pipe quantitatively and qualitatively. We manufactured the bended heat pipes and measured thermal performance during the transient. The steady-state and transient computational capability of LUHPIS code were validated with the experimental data [2].

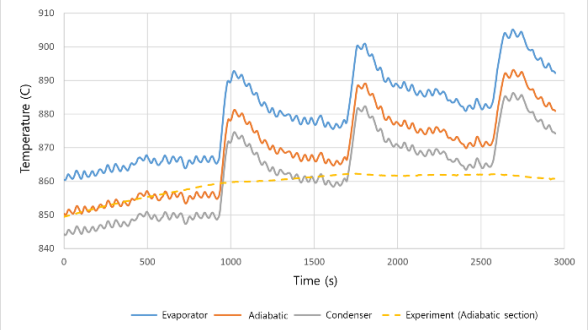

Fig. 4. Temperature distribution of the bended heat pipe during the transient test and calculation.

After acquiring heat pipe technology, we started to develop technology for the heat pipe assembly as well as coupling to a sterling engine, which is under development by Korea Institute of Machinery and Materials (KIMM).

2. Methods and Results

2.1 Reactor Concept

KAERI developed design requirements considering a Korean launch vehicle [4].

- Life time > 10years
- Operating temperature: 700-750℃
- Thermal power: 5kWth
- U-235 enrichment < 20.0wt%
- Mass < 1200kg, height < 5m, diameter < 2m
- Shielding design to protect the reactor system

2.2 Heat Pipe Assembly Test

We are making test section of heat pipe assembly for producing data to validate the concept of the heat pipe cooled space reactor as well as core heat transport analysis code, HEPITOS [5]. The HEPITOS code coupled with the LUHPIS code is being developed to predict temperature distribution inside the core.

Six heat pipes in the test section transfers heat from the electric heater to cooling device. The heat of maximum 2.5 kW will be removed by each cooling channel. The steady-state and transient test will be conducted over 650℃ of operating temperature, which means the surface temperature of heat pipes.

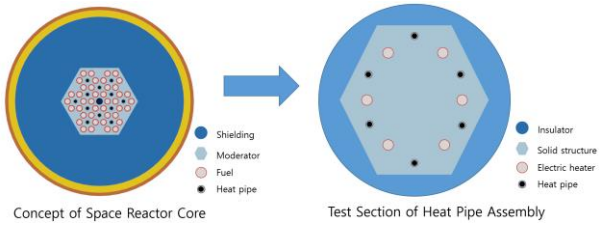

Fig. 5. Concept of heat pipe assembly for validating design technology of heat pipe cooled space reactor.

2.3 Coupling sterling engine to heat pipe assembly

Test for coupling the sterling engine to the heat pipe assembly is also planned. Three bendable heat pipes are connected to a sterling engine. It is planed that the coupled sterling engine produce electricity of 250 W at the same operating temperature. KIMM is going to develop the sterling engine and prepare the separate effect tests.

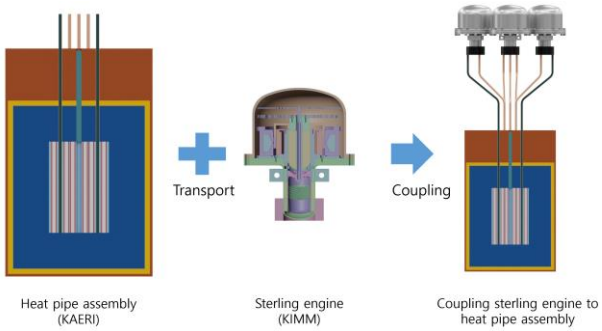

Fig. 6. Test concept for coupling the sterling engine to heat pipe assembly.

3. Conclusions

Fission surface power is needed for the manned space mission on the moon. We developed design requirements, concept and novel design heat pipes for heat pipe cooled space reactor. We started to manufacture the test section of heat pipe assembly for validating the concept of a heat pipe cooled reactor as well as our design tools. Test of electricity generation through coupling sterling engine to heat pipe assembly is also planned.

ACKNOWLEDGEMENT

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