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Abnormal Behavior of Motor Surface Temperature of Canned Pump along Increasing Fluid Temperature

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1. Introduction

For an initial nuclear fuel loading in the open pool research reactor, the commissioning of the reactor itself and the main systems relevant to the reactor has been proceeding to check its performance. The main fluid systems are composed of a primary cooling system, a pool water management system, an emergency water supply system, a hot water layer system, and a heavy water system. Unlike a nuclear power plant, the research reactor is designed and operated for a multi-purpose utilization: radio-isotope production, irradiation facility operation, cold or thermal neutron production for neutron scattering instruments, etc. For these multi-purposes, a heavy water system (HWS) or other reflector is required to moderate fast neutrons into thermal neutrons effectively. In this paper, an abnormal behavior of the motor surface temperature of the canned motor pump, discovered during a commissioning, is shown along an increasing fluid temperature including its estimated reasons to avoid the same phenomenon in the manufacturing stage.

2. Results and Discussion

Along the research reactor is on a power operation after a fuel loading, the heavy water, circulated through the heavy water vessel in the reactor pool, becomes radioactive through the conversion of the heavy water into the tritiated water. The heavy water system is designed to minimize the tritium concentration in the air of equipment room. To avoid the continuous leakage through the mechanical seal and the contamination by the lubricant in the rotating part, the canned motor pump was selected to circulate the highly pure heavy water on the closed loop. [1]

For the pump performance check, the test and inspection are focused on the pump and motor performance including the vibration, noise, temperature and so on. Those test reports were satisfied to meet the acceptance criteria in terms of its performance. The manufactured pumps, one for operation and the other for standby, were installed on the site for a commissioning.

2.1 Pump performance of pump-001/002

During the commissioning stage, the pump had been continuously operating for two hours to check the flow rate, suction pressure, discharge pressure, total head, three-dimensional vibration velocity, and bearing housing temperature in terms of performance, stability, and integrity. The pump-001/002 had shown to meet the acceptance criteria. Although the fluid temperature is increasing, those test results didn't show any difference from the acceptance criteria. In terms of the pump performance, the manufactured pumps are suitable to operate in the heavy water system; however, it has not been known yet how the motor surface temperature increment along an increasing fluid temperature affects a long-term integrity. Also, it is necessary to check how high temperature is reaching under the variation of the fluid temperature.

2.2 Motor surface temperature trend in pump-001

The motor surface temperature of the pump-001 has been investigated under the variation of the pool temperature because the majority of the heavy water holdup is in the heavy water vessel in the reactor pool. Fig. 1 and Fig. 2 show the motor surface temperature trend at 20°C and 30°C of the pool temperature, respectively.

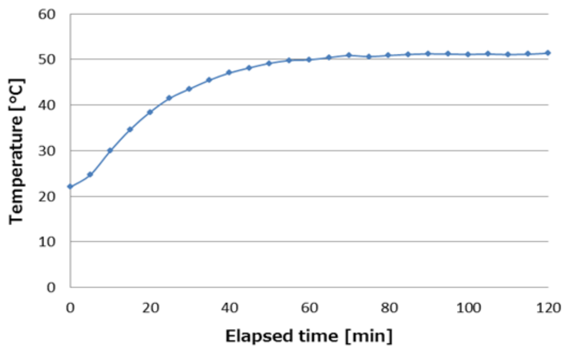

Fig. 1 Motor surface temperature of pump-001 at 20°C

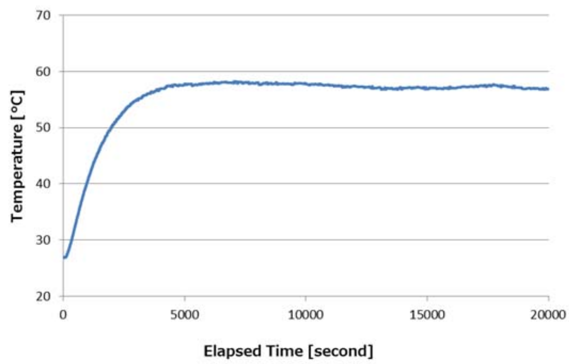

Fig. 2 Motor surface temperature of pump-001 at 30°C

In comparison between Fig. 1 and Fig. 2, the difference of the motor surface temperature between the pump-001 and pump-002 is about 5°C under 10°C increment of the pool temperature.

2.3 Motor surface temperature trend in pump-002

In the case of the pump-002, the motor surface temperature trend shows the different behavior as presented in Fig. 3 and Fig. 4.

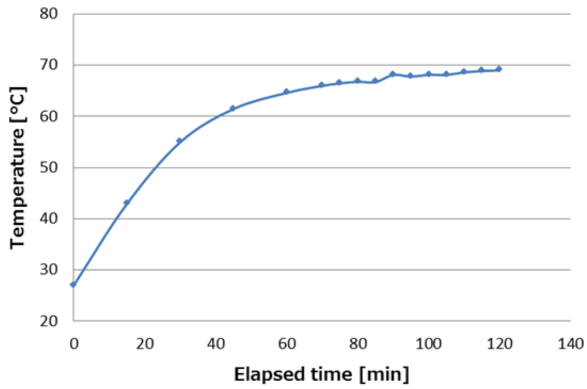

Fig. 3 Motor surface temperature of pump-002 at 22°C

Unlike the pump-001, the motor surface temperature of the pump-002 is not saturated for two hours operation at 22°C. Also, the approaching surface temperature is 69°C with 18°C temperature difference from the pump-001.

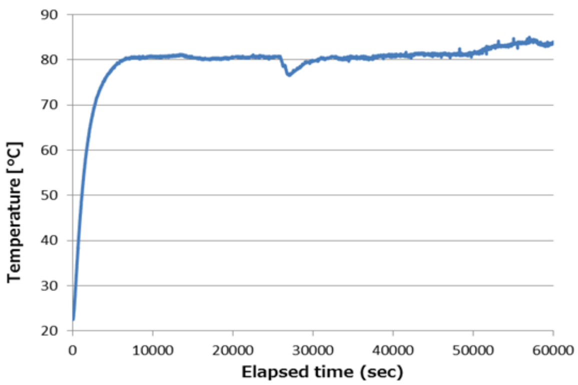

Fig. 4 Motor surface temperature of pump-002 at 32°C

As shown in Fig. 4, the motor surface temperature seems to be saturated at 81°C for a long time and then is increasing again more than 84°C when the pool temperature is 32°C. When the design heavy water temperature of 44°C is considered, the motor surface temperature is estimated at approx. 100°C. Because of this estimated high temperature, the modification on the pump was considered to avoid any potential problem caused by the heavy water boiling inside the pump.

2.4 Motor surface temperature trend after modification

The reasons why the pump-002 has an abnormal behavior are estimated with (1) not enough cooling flow circulation through the rotor and stator inside the pump or/and (2) pump operation at an allowable maximum rated current with no design margin.

To solve this abnormal behavior, the canned pump has been changed to have more cooling flow through the gap between the rotor and the stator and to increase the rated current on the premise of no change of process parameters such as the total head, discharge pressure, rated flow rate, and so on.

After modification on the pump, Fig. 5 shows that the motor surface temperature trend is stable and saturated within a short time and not increasing along the elapsed operating time.

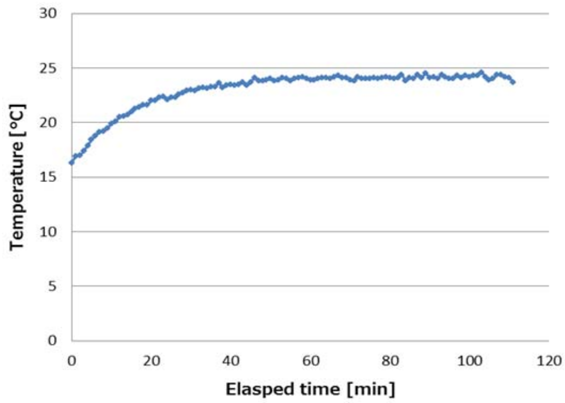

Fig. 5 Motor surface temperature of modified pump at 18°C

3. Conclusions

Although how the increment of the motor surface temperature affects its long-term integrity along the fluid temperature variation, this abnormal behavior is not accepted because this may cause any potential problem in the heavy water system filled with the radioactive heavy water. After modifying the internal of the canned pump, the temperature increasing rate on the pump motor surface is much lower and saturated within a short time. The gap between the fluid temperature and the motor surface temperature becomes much narrower about 6°C in comparison with the former operation data (more than 30°C). That is, the motor surface temperature shall have a smaller difference from the working fluid temperature to secure a long-term integrity during the design life time, and it is also recommended to measure the temperature difference between the working fluid and the motor surface temperature during a manufacturing stage.

REFERENCE

[1] Jungwoon Choi, "System Description of Heavy Water System", JR-321-KF-414-001.