Performance and NPSHre Test of the JRTR Primary Cooling System Pump

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1. Introduction

Primary cooling system pump circulates the coolant from the reactor structure to the heat exchanger in order to continuously remove the heat generated from the reactor core in the research reactor as shown in Fig. 1. The secondary cooling system releases the transferred heat to the atmosphere by the cooling tower.

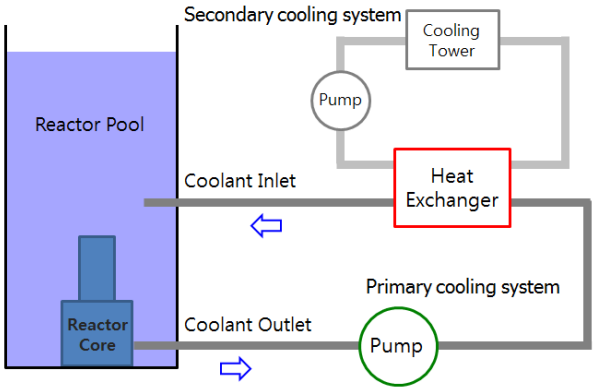

Fig. 1. Schematic diagram of the flow path of the coolant in an open-pool type research reactor

In the system design stage, rated head and flow rate of the primary cooling system pump are calculated considering the thermal design flow rate, system resistance curve, uncertainty of the measurement, aging effect of the plant and so on. After manufacturing the pump, performance and NPSHre shall be tested to meet the pump and system design requirement. During the pump test, mechanical conditions shall be also checked to confirm integrity of the pump.

2. Pump Performance and HPSHre Test

In the previous research, the type of the primary cooling system pump was determined based on a slope of the pump performance curve, NPSH (Net Positive Suction Head) margin, flywheel design speed and pump size. Centrifugal pump with a non-dimensional specific speed of 0.59 [-] and specific diameter of 4.94 [-] was determined as the primary cooling system pump [1] ~ [3].

The Primary cooling system pump consists of the pump casing, bearing housing, flywheel and motor as shown in Fig. 2.

Pump performance test is performed in accordance with the ANSI/HI and KEPIC for centrifugal pump test and In-service test of pumps [4] ~ [6].

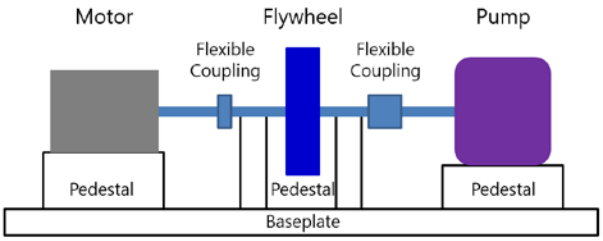

Fig. 2. Schematic drawing of the pump

The accuracy of instrument shall be certified by the authorized accreditation scheme and used within its credited calibration duration. Instruments shall provide the acceptable fluctuation and accuracy as listed in Table 1 [4] ~ [6]. Instrument list are described in Table 2.

A vacuum pump is used to depressurize the pump suction for the NPSHre test.

Table 1. Fluctuation and accuracy

Measurement	Acceptable fluctuation of readings ±% of the values	Accuracy of the instrument as a ±% of the values
Flow rate	2.0	1.5
Suction head	2.0	0.5
Discharge head	2.0	0.5
Input power	2.0	1.5
Pump Speed	0.3	0.3
Vibration	-	5

Table 2. Instrument list

Instrument	Accuracy	Maker
Venturi Flow Meter	± 0.28 %	ABB
Pressure Transmitter	± 0.3 kPa	ABB
Torque Detector	± 0.13 %	ONO SOKKI
Speed meter	± 0.6 rpm	TESTO
Vibration meter	± 5%	IMV
Sound Level Meter	-	CEL
Digital Thermometer	-	TASCO

3. Test Results

Figure 3 shows the pump performance curve. Fluctuation of the values at the design flow rate is described in Table 3. All test results satisfy the requirements

Pump mechanical conditions are reported in Table 4. All measured values are below the acceptable value.

NPSH margin is 2.0 with NPSHa of primary cooling system [7].

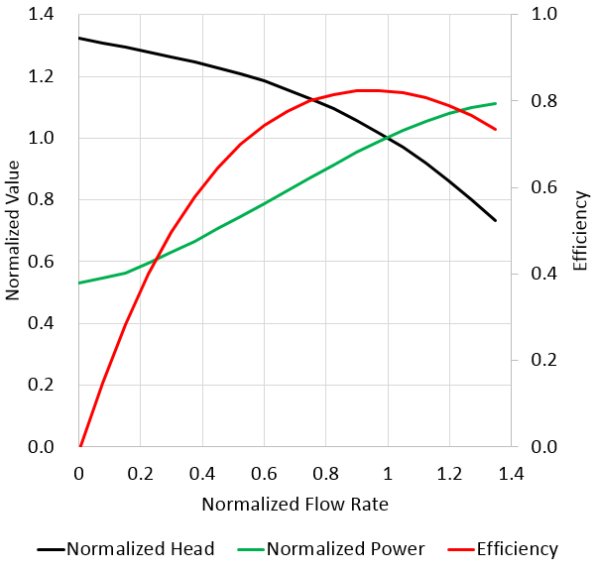

Fig. 3. Pump performance curve

Table 3. Fluctuation of the values

Measurement	Suction Head	Discharge Head	Flow rate	Power
Acceptable range	± 2%	± 2%	± 2%	± 2%
Results	± 0.00%	± 0.07%	± 0.18%	± 0.13%

Table 3. Pump mechanical conditions

Instrument	Acceptable value	Results
Pump vibration	< 3.0 mm/s	1.41 mm/s
Flywheel vibration	< 3.0 mm/s	0.39 mm/s
Motor vibration	< 3.0 mm/s	0.95 mm/s
Pump bearing temperature	< 80 °C	38 °C
Flywheel bearing temperature	< 80 °C	38 °C
Motor bearing temperature	< 80 °C	44 °C
Sound level	< 85 dB	82.6 dB

4. Conclusions

Performance and NPSHre test of the primary cooling system pump are accomplished in accordance with the code and standard. All test results comply with system design requirements and acceptance criteria.

REFERENCES

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Nomenclature

d_s	Specific diameter, $D\cdot(g\cdot H_d)^{0.25}/Q_d^{0.5}$, [-]
g	Acceleration of gravity, 9.81[m/s^2]
n_s	Specific speed, $\omega\cdot Q_d^{0.5}/(g\cdot H_d)^{0.75}$, [-]
D	Diameter of the impeller outlet, [m]
H	Pump head, [m]
H_d	Pump head at the design point, [m]
H_{ratio}	Normalized pump head, H / H_d [m]
N	Revolutions per minutes, [rpm]
N_{margin}	NPSH margin, $NPSH_A$ / $NPSH_R$, [-]
NPSH	Net Positive Suction Head, [m]
$NPSH_a$	Available NPSH, [m]
$NPSH_{re}$	Required NPSH, [m]
P	Power, [kW]
P_d	Power at the design point, [kW]
P_{ratio}	Normalized power, P / P_d, [-]
Q	Flow rate, [m^3/s]
Q_d	Flow rate at the design point, [m^3/s]
Q_{ratio}	Normalized flow rate, Q / Q_d, [-]
ω	Pump speed, [rad/s]