Flow Rate Measurement of the Primary Cooling System Pump through the Motor Performance Data during Commissioning

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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.

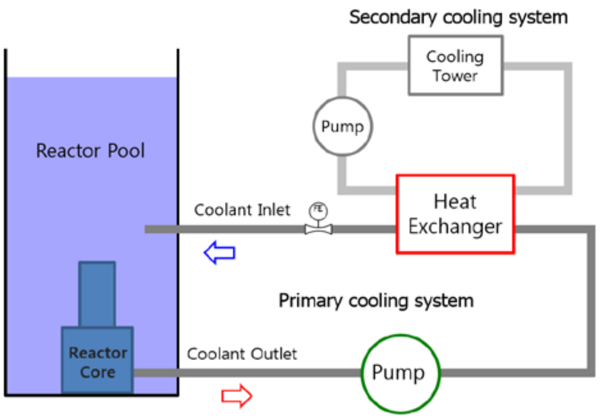

Fig. 1. Schematic diagram of the flow path of the coolant in an open-pool type research reactor

During normal operation, flow rate of the primary cooling system is measured by the venturi flow meter installed in the pipe.

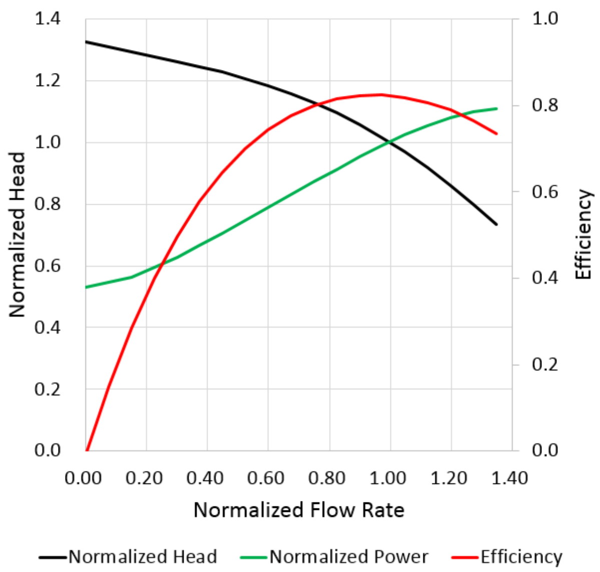

Fig. 2. Pump performance curve

Pressure gauges are also installed at the suction and discharge of the pump to measure the flow rate by using the relationship between the pump differential pressure and flow rate of the pump performance curve as shown in Fig. 2.

Before entering the system performance test stage, system shall be flushed to get rid of any foreign materials inside equipment and piping. Temporary system is designed with the expansion tank as shown in Fig. 3. At that time, it is difficult to measure the system flow rate because venturi flow meter and permanent pressure gauges are not installed.

During flushing, system flow rate shall be measured to prevent the cavitation and mechanical damage due to the vibration in the pump. Ultrasonic flow meter is installed on the piping in consideration of the required straight running length. Digital power meter is installed on local motor control center. Temporary pressure gauges are also installed at the suction and discharge of the pump for local indication.

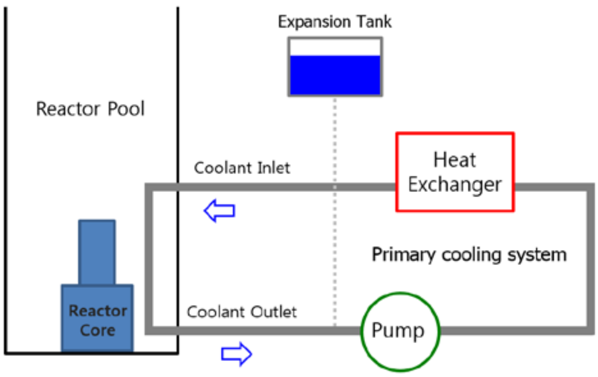

Fig. 3. Schematic diagram of temporary system for flushing

2. Flow Rate Measurement

In the previous research, the type of the primary cooling system pump was designed 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] ~ [4].

Flow rate is measured directly by the ultrasonic flow meter. But, alternative measurement method is required to obtain the reliable value of the flow rate. Pressure gauges are widely used for this purpose. But, high accuracy pressure gauge and stable flow field are required to obtain the accurate flow rate across the pump.

In this research digital power meter is also used to measure the flow rate based on the motor and pump performance data.

Pump performance test is performed in accordance with the ANSI/HI and KEPIC for centrifugal pump test and in-service test of pumps [5] ~ [8]. Relationship between the flow rate and break horse power is obtained from this test results.

Motor test is performed in accordance with the KEPIC EEB 2200 and NEMA MG 1 [9] ~ [10]. Relationship between the break horse power and motor input power is obtained from this test results. Therefore, flow rate of the pump can be measured by using the motor input power as shown in Fig. 4.

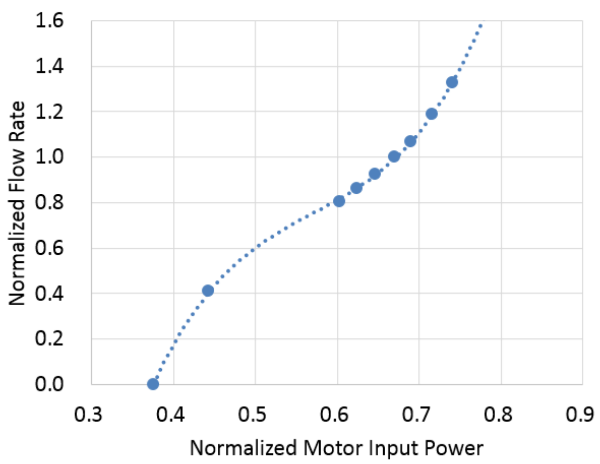

Fig. 4. Mortor input power and flow rate curve

3. Measurement Results

Table 1 shows the measurement results of the system flow rate during flushing stage. Flow rates measured by the ultrasonic flow meter and digital power meter are almost same. But, flow rate measured by pressure gauge is about 10% higher than other values.

Table 1. System flow rate

Measurement	Ultrasonic flow meter	Motor input power	Pressure gauge
Normalized Flow rate	1.15	1.16	1.24

4. Conclusions

Flow rate of the primary cooling system is measured through the ultrasonic flow meter, pressure gauge and digital power meter before installing the venturi tube flow meter. This flow rate is used to operate the temporary system stable and to inform the system designer as a reference data for the system performance test.

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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]