Heat Balance on the PULSTAR Reactor

NE 400 Laboratory

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Introduction

The ex-core neutron detectors used to measure power in nuclear power plants are typically calibrated by performing a heat balance on the plant's primary coolant system. This approach is also used to calibrate the neutron detectors on the PULSTAR nuclear reactor at NCSU. The power output can not be measured directly, but can be inferred from the flow rate and temperature change across the reactor by

$$\dot{Q} = \dot{m} C_p (T_H - T_C)$$

where $\dot{m}$ is the core flow rate, T_H is the core exit temperature and T_C is the core inlet temperature. The PULSTAR is a pool type reactor, where the pool provides both shielding and a source of cooling water. In the PULSTAR, flow enters the top of the reactor from the pool and flows downward through the core. The coolant then enters an outlet plenum where it is directed to a delay tank before entering a heat exchanger where the core heat is transferred to a secondary cooling loop. The cold fluid is then pumped back to the reactor pool. A diagram of the primary cooling circuit is given below. Coolant temperatures are measured by Resistance Temperature Devices (RTDs) located in the pool, in the piping just downstream of the core exit, and across the heat exchanger. Flow is measured in the piping between the core exit and the delay tank. In the absence of losses, the temperature difference between the pool and the RTD downstream of the core should equal the temperature difference across the heat exchanger. In this lab, temperature measurements will be made at power levels between 1 Mw and 100 Kw. The corresponding heat transfer rates will be compared to power levels recorded by the power range neutron detectors.

Experimental Procedure

1) The PULSTAR will be operated at steady state power levels between 1 Mw and 100 Kw, in 100 Kw increments.

2) The PULSTAR's data acquisition system is capable of sampling and displaying a number of key operating parameters as a function time. Steady state operation can be assumed when the monitored coolant temperatures become constant following a power change.

3) Once steady state has been established at a given power level, core power, bulk pool temperature, core exit temperature and the temperatures across the heat exchanger will be logged 1 time per second for a 1 minute sampling period by the reactor's data acquisition system. Core flow can be assumed constant at its nominal value.

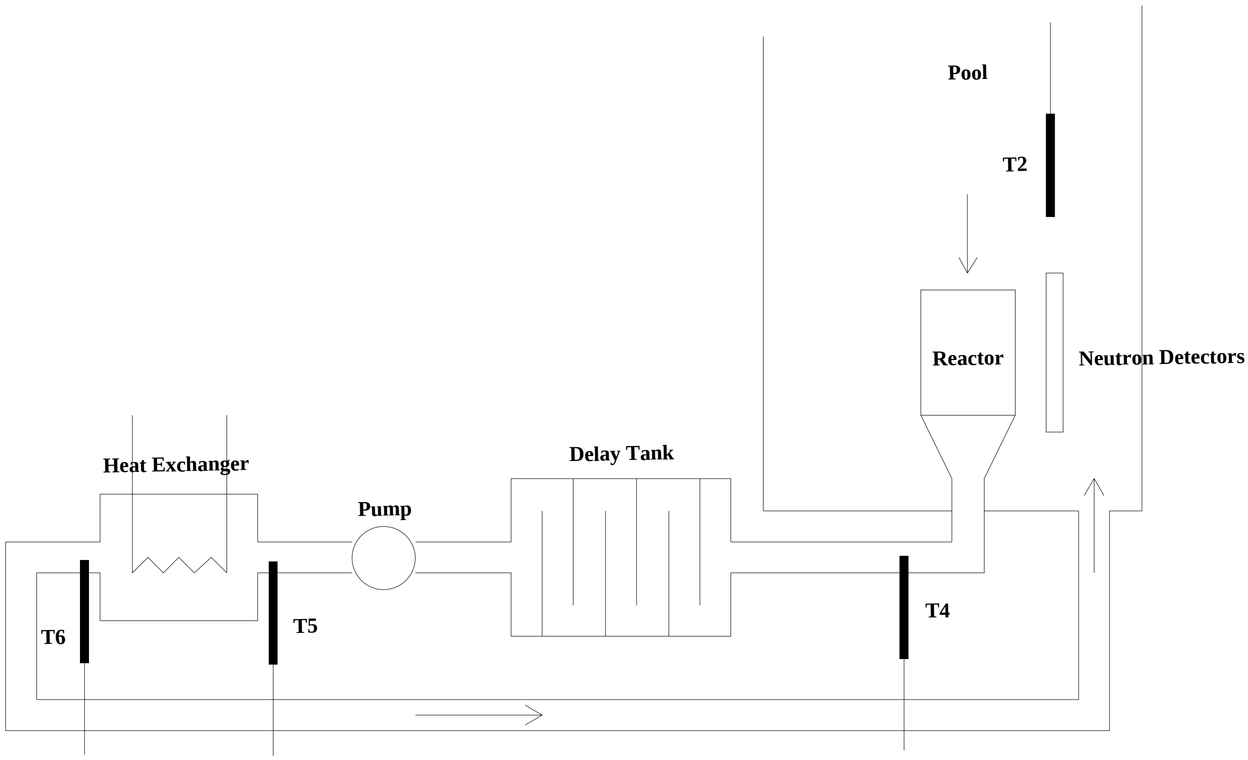
Data Analysis

1) Compute the average temperatures and the average neutron power along with their associated uncertainties from the measured data at each power level.

2) Compute the heat transferred from the average core inlet and outlet temperatures, and the average temperatures across the heat exchangers according to

$$\hat{\dot{Q}} = \dot{m} C_p (\overline{T}_H - \overline{T}_C)$$

3) Compare the heat transfer rates obtained by the two energy balances to the neutron power as determined from the ex-core neutron detectors.



Primary Cooling Circuit