HEAT REMOVAL MECHANISMS IN NUCLEAR REACTORS UNDER ACCIDENTAL CONDITIONS

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1. Abstract:

Natural circulation is an important heat removal mechanism in nuclear reactors. During off normal conditions this mechanism can retain integrity of core. Different mathematical models were studied. Preliminary work is done in order to understand computer code developed in house. Results of computer code were analytically verified. Data generated by natural circulation experiments was analyzed and found to be in agreement with numerical results for single phase natural circulation experiments. Steady state analysis is done for system. Theoretical analysis of reflux condensation is done to guess at what power flooding limit will be crossed. Single phase natural circulation results are successfully verified by numerical model. Condenser code has been successfully verified for experimental data. Two phase natural circulation requires different models for successful numerical verification. Reflux condensation data generated can be experimentally verified.

2.1 Introduction

It consists of horizontal test section simulating in full scale the pressure tube of 220 MW Indian PHWR. The heater is energized by a high current power supply to generate a maximum 60 kW heat. Exiting hot fluid is cooled with the help of condenser using water as a coolant. The heat acquired by water is discharged into the atmosphere with the use of cooling tower.

Various components of the experimental setup may be classified into the following sub systems.

1. Primary coolant system
2. Secondary coolant systems
3. Electrical power systems
4. Instrumentation and Control

2.2 Primary Coolant System

The major components in the system are
1. Test section assembly
2. Condenser
3. Primary pump

3.1 Test section assembly

The test section assembly forms an important constituent of the test facility. It consists of a central heating element and surrounding shell. The intervening annulus forms the passage for fluid flow. A 6 m long, 50.8 mm (2 inches) stainless steel tube was used as the heater. Two cylindrical copper bus bars were silver brazed on either end as shown in Fig 3.2 Power supply was connected t o the buses through flexible copper bus bars. Shell was made up of transparent glass section to visualize flow patterns. These glass sections have 77.5 mm inner diameter and 5 mm thickness and 1 m length. Five glass sections and one bellow a central support system section and two stainless steel sections along with the inlet and outlet housings formed the shell of the test section assembly. The inlet and outlet housings formed the shell of the test section assembly. The inlet and exit housings were provided with stuffing boxes to allow for free thermal expansion of heater while at the same time providing leak tightness.

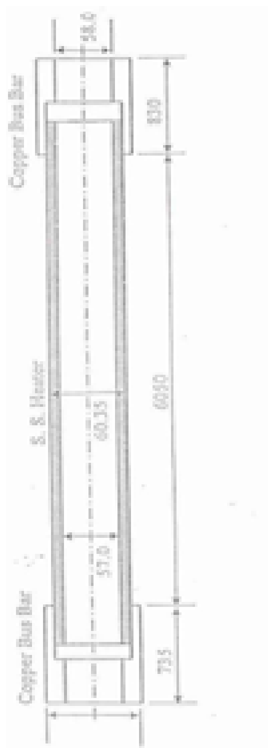

Fig. 3.2 Schematic view of the heater assembly (all dimensions are in mm).

4.EXPERIMENTAL RESULTS AND DISCUSSION

4.1 Experimental Procedure

Experimental set up is filled up with water. The primary pump is run for 3 to 4 minutes for homogenizing the fluid. Certain secondary flow rate is initiated in U tubes and power is supplied in heater section. For given power steady state is obtained i.e. primary inlet temperature does not change with time. Experiments are then repeated for different power levels. During experiments it is observed that primary inlet temperature increases with increase in power supplied to setup.

4.2 Analysis of Single Phase Natural Circulation:

Data generated by experiments is analysed using numerical procedure developed. Fig. 4.3 shows graph of temperature variation of primary inlet and primary outlet temperature for 9.5 kW, 6-8 kW.

Fig. 4.2 shows variation of inlet and outlet temperature of water in test section of experimental set -up for 9.5 kW, after power supply inlet temperature T in will rise gradually and at steady state it will be at a constant value. Outlet temperature of water Tout from test section will rise after one peak it will gradually settle at steady state value. Sudden dip in T out and T in corresponds to change in ice in which thermocouple wires are immersed.

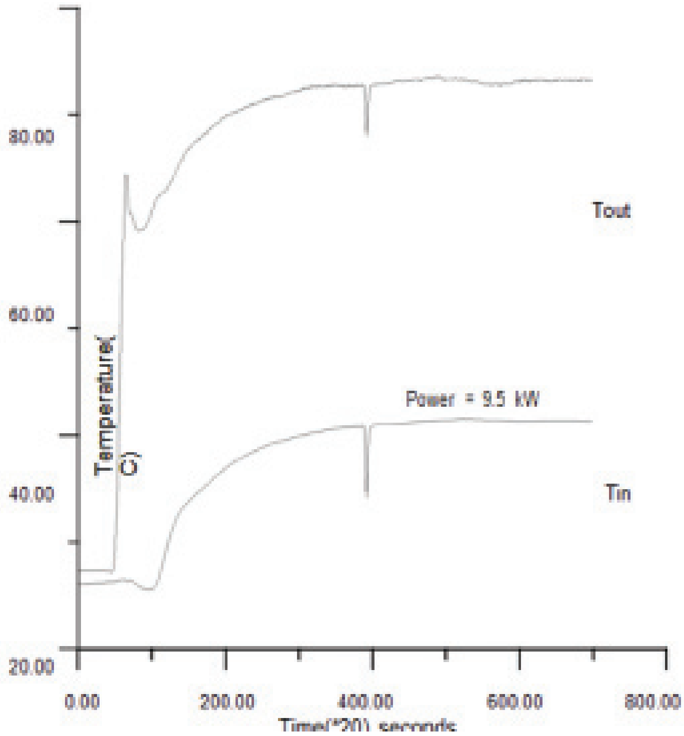

Fig. 4.2 Temperature variation with time in single-phase natural circulation for 9.5 kW

CONCLUSION AND FUTURE WORK

5.1 Conclusion

For single phase natural circulation experiments results obtained were verified by numerical methods. For two phases natural circulation mass flow rate observed experimentally and numerically are showing large difference, more investigation is required to verify mass flow rates numerically. Reflux condensation experiments could not be carried out due to stratification in heater area. Condenser code is satisfactorily verified for experimental data.

5.2 Future Work

1. Mass flow rate for two phase natural circulation by numerical procedure is lower. For verifying this mass flow rate different model may be used for calculation of two phase friction multiplier.
2. Turbine flow meter should be calibrated for low mass flow rates so as to compare mass flow rates in single phase natural circulation experiments.
3.Data generated for reflux condensation can be verified experimentally.
4.Use of vertical glass section may help to observe flow patterns in vertical tube.
This will give detail idea regarding reflux condensation phenomenon.

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