

CHARACTER OF PRESSURE SURGES IN THE MAIN STEAM LINE OF A VVER-TYPE PWR AT THE PMK-2 TEST FACILITY

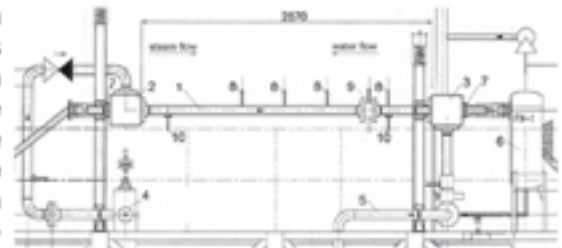
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> Introduction

Some of the accident scenarios discussed for VVER-440 reactors assume an overfeed of the secondary side of the steam generators by water coming either from the primary side or from the feed water system. The present work was initiated to study this phenomenon experimentally. For this purpose the PMK-2 test facility of KFKI-AEKI Budapest, an integral thermohydraulic model of a VVER-440 /213, was extended by a steam-line model, which is equipped with a novel two-phase flow instrumentation as well as fast pressure and displacement transducers.

> Description of the test facility

The water hammer test section consists of a 2.87 m long horizontal pipe with an inner diameter of 73 mm designed for a maximum pressure of 16 MPa. The end of the test section is connected with the condenser unit of this test facility, which substitutes the turbine of the real plant. The test section can be isolated by two valves; one is located in the connection with the steam generator head, the other in the connecting line towards the condenser. The water injection is initiated by opening a valve in the injection line (inner diameter 24 mm). The locations of mesh-sensor, needle probes and fastpressure transducers are indicated in the figure.



> Special instrumentation / mesh sensor

The sensor consists of two grids of 12 parallel electrode rods placed into the flow in a short distance behind each other. The measuring plane is located in the axial gap (2 mm) between the electrode planes. A photo of the sensor is shown a special design for an application at high pressure up to 7 MPa and a temperature of up to 285 °C was developed. The sensor is equipped with an integrated cooling channel. In this way the sealing elements are kept at a temperature below 180 °C.



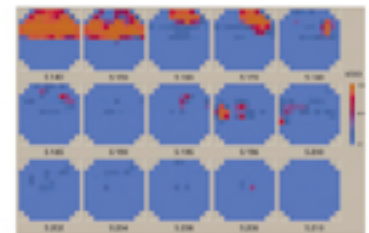
> Special instrumentation / local void probes

The principal scheme of a needle probe with integrated thermocouple is shown in the figure. The temperature is measured by a microthermocouple of 0.25 mm diameter, the shroud of which is used as electrode for the measurement of the electrical conductivity of the fluid. In this way, the phase (liquid or gas) detection is carried out in accurately the same position, where the temperature is measured.



> Test conditions / test results

In figure the void collapse is shown in a higher time resolution. The water slug that arrives at the sensor position contains some vapor bubbles. At $t = 5.210$ s the entire cross section is filled with water.

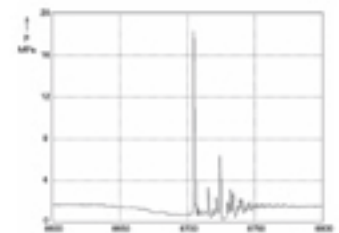


TEST PARAMETERS

Run	Steam pressure	Water temperature	Water flow rate
	MPa	°C	kg/s
E31	0.98	30	1.20
E32	1.15	30	0.66
E33	1.45	25	1.01
E34	1.50	30	1.66

TEST RESULTS

Run	Maximum pressure	Pressure increase
	MPa	MPa
E31	12.99	12.01
E32	2.75	1.60
E33	17.43	15.98
E34	18.35	16.85



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