Static Magnetic Field Disturbance near Water – Water Nuclear Reactor Core at Attainment of Power

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Abstract **– In the course of works on research of electromagnetic conditions in a physical hall of a water-water nuclear reactor an increment of a static magnetic field was revealed at a rise of reactor power in the area adjacent to an active zone. The maximal value of the increment amounted to 0.012 A/m on reaching 2500 kW power and 0.065 A/m on reaching 7000 kW (measurements are conducted on two different reactors).**

Key words: nuclear reactor, nuclear power, active zone, magnetic field, magnetic field sensor, magnetic field disturbance.

1. Routine of Experiment on Measurement of Operating Nuclear Reactor Magnetic Field

Procedure of measurement of an operating nuclear reactor magnetic field consisted in the following:

- A magnetic field sensor (MFS) was placed in the near zone of reactors № 1 and № 2 at 2 m radius away from the active zone (Figures 1, 2).

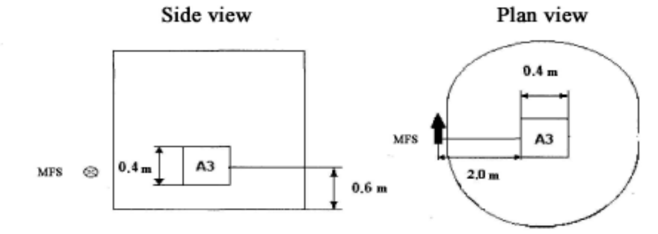

Fig. 1 Layout of the magnetic field sensor location on the nuclear reactor 1 of up to 2500 kW power (Experiment 1).

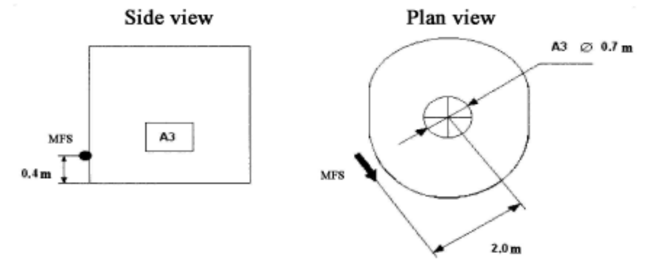

Fig. 2 Layout of the magnetic field sensor location on the nuclear reactor 2 of up to 7000 kW power (Experiment 2)

- Thirty (30) minutes prior to start of attaining the reactor power, warm-up of a measuring equipment was carried out in order to avoid superposition of warm-up effect on the investigated phenomenon effect.
- Presence of people in the physical hall is prohibited during the reactor start-up, so an experimenter was watching actions of an operating personnel directly from a control room marking the time of the main stages of setting the reactor up to its power (movements of rods, activation of pumps) and various background influences (a beam-crane operation etc.).
- The magnetic field sensor indications registered by an automatic recorder were taken continuously while reaching nominal nuclear power.
- The registered data were digitized and analyzed at the final stage.

A. Magnetic Field Sensor

A magnetic field sensor (MFS) of fluxgate type was used during the experiments. The sensor of such type provided the required level of sensitivity in working bandwidth. The sensor sensitivity and bandwidth are given in the table.

Sensor type, Marking	Sensitivity V/(A/m)	Bandwidth, Hz
Fluxgate MFS	0.040	0-0.1

B. Recording Equipment

An automatic recorder of XУ Recorder 26000 type was used as recording equipment.

Name	Time base, s/cm	Working sensitivity, mV/cm	Compen-sation
XY Recorder 26000	240	0.5	+

2. Experimental Investigation of Phenomenon of Operating Nuclear Reactor Magnetic Field Occurrence

Checking of the magnetic field sensor in laboratory-like environment and directly in a point of the magnetic field measurement was made prior to measurements of the magnetic field near the nuclear reactor. Characteristic oscillograms are given in Figures 3, 4.

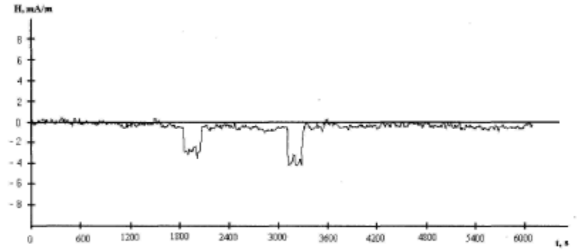

Fig. 3 The magnetic field sensor operation in the Research Institute of Pulse Technique laboratory (checking of the magnetic field sensor).

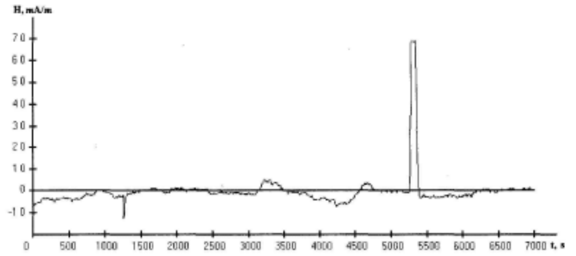

Fig. 4 The magnetic field sensor operation on the reactor directly in a point of the magnetic field measurement (the reactor is in subcritical state). Warm-up area (0-1500 s), the sensor response to installation work conducted on the reactor (2500-4800 s, 5100-5400 s), are visible.

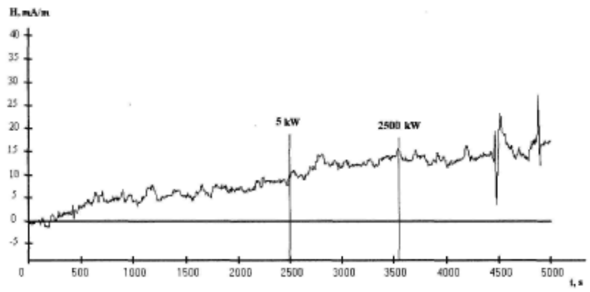

Fig. 5 A curve of the magnetic field change in the near zone of reactor 1 during the process of attaining of up to 2500 kW power. Zero mark of time corresponds to the start of the reactor power rise, 5 kW power – 2500 s, 2500 kW – 3500 s.

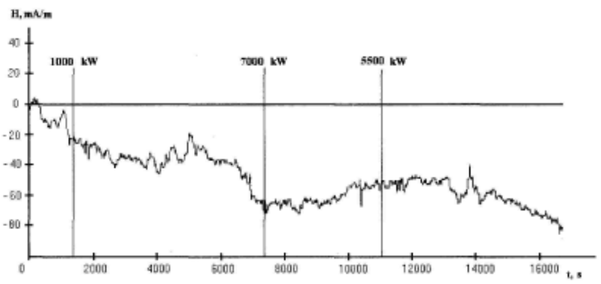

Fig. 6 A curve of the magnetic field change on reactor 2 of up to 7000 kW power. Zero mark of time corresponds to the start of the reactor power rise; 1000 kW power – 1300 s, 7000 kW power – 7300 s, 5500 kW power – 11000 s

Registration of the magnetic field increment during the process of attaining the reactor capacity was carried out after checking of the sensor. Characteristic oscillograms are given in Figures 5, 6.

Various assumptions about nature of change of the initial magnetic field - which were based on influence of the reactor design nonstationary elements upon it - were checked during investigation. In the first place, an assumption about influence of absorption rods on the magnetic field during their movement at attainment of power was checked. The field change connected with its spatial redistribution must be observed during movement of steel constructions. So, it was reasonable to assume that the magnetic field structure was influenced by the absorption rods. Monotonous nature of the field change while attainment of the reactor power justified this assumption. Indeed, several groups of rods are taken from the active zone when the reactor reaches critical state and then rises to its power. An electric motor transmitting motion to steel wire ropes that draw out the rods at ~1 mm/s speed sets them in motion.

Raise lasts about 30 minutes. At first glance, movement of the rods may be taken for a cause of the magnetic field change. However, this hypothesis was not confirmed during power drop experiment, when all rods are drawn down to the active zone for short time period (~10 min.) - Fig. 7. At that, abrupt change of the field does not occur, what contradicts the model of such change of the magnetic field. This fact tells about lack (at least, in registration range) of influence of the rods upon the magnetic field change.

Another assumption was connected with operation of the pumps supplying coolant to cooling circuits of the reactor. Version about the magnetic field change because of actuation of the pumps’ electric drives was stated. A fact of the magnetic field change before actuation of the pumps and lack of any distortion of the effect that could be connected with actuation of the pumps became a disproof of this hypothesis.

According to preliminary estimates, processes connected with working state of the reactor active zone are the magnetic field source.

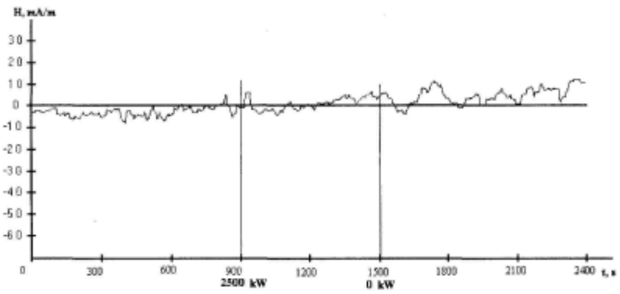

Fig. 7 Curve of magnetic field while power drop.

3. Conclusion

The phenomenon of the magnetic field occurrence near the active zone of the water-water nuclear reactor while its power rise was revealed. Maximum value of the phenomenon amounted 0.065 A/m when reaching 7000 kW power. Mechanism of the magnetic field occurrence is not clear. It is expedient to continue investigations on ascertainment of nature and mechanisms of operating nuclear reactors’ magnetic field generation in order to develop devices and methods for additional control of functioning of nuclear reactors included in configuration of various energy installations.

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