**Development and experiments at large-scale installation for heating and retention of corium. Task I: medium-scale experiment**

**Large scale corium experiment**

**(~1000-1200 kg)**

To experimentally test melt behavior, melt interaction with concrete at a severe accident at NPP it is planned to develop a large-scale installation that is to heat and retain melt of materials of reactor core EPR along with the complex of diagnostic and measuring equipment. To obtain the adequate results of the research of the melt interaction with concrete, the installation should have the following characteristics: melt volume -150 l, melt mass ~1200-1300 kg, melt temperature –~2500-3000˚C, heat fluxes towards walls and a bottom of a catcher ~100 kW/m2, melt retention time –1-2 hours.

Reactor core melt materials are planned to contain (mass %): 20- 30% UO2; 40-50% ZrO2; 30-40% Fe.

**Medium scale corium experiment**

**(~100-120 kg)**

1. Total scheme and geometry of medium scale experiment

1. As a model of a core-catcher we will use a cylindrical concrete tank with sizes:

- core-catcher’s internal diameter ~0.3-0.35 m;

- core-catcher’s height ~0.5-0.6 m;

- thickness of core-catcher’s walls ~0.2-0.3 m;

- thickness of core-catcher’s bottom ~0.2-0.3 m.

2. The experiment will begin with initiating the hard pyrotechnic composition – PTC (~25-30 kg), located in the core-catcher at the initial time. Hence an initial molten pool will be created.

3. Further, pyrotechnic briquettes are thrown into the existing molten pool (from height ~1m) with a frequency of ~0.15-0.2 kg/s. Accordingly, we accomplish the following goals:

- the melt mass is increased (up to ~120-130 kg within ~10-12 min);

- at the expense of energy release from combustion of briquettes inside the melt we provide the required heat fluxes to the walls and the bottom of the core-catcher (~100 kW/m2 within ~10-12 min);

- the necessary melting temperature is provided for (~2500-3000˚C).

4. Uniformity of energy release in the melt will be achieved by throwing briquettes into different areas of the melt through holes in the protecting cap.

5. Additional melt heating will be made by means of the ~5 gas burners located at regular intervals over the catcher circumference at height of ~10-15 cm above the molten surface. Total thermal capacity of the burners is 20-30 kW.

6. Height of the molten pool in 10-12 min after the beginning of the experiments will reach~0.15-0.2 m; the volume of the melt will amount up to ~15-18 l. The melt density 6-7 kg/cm3.

1. PTC and corium composition

1. To create the molten pool and provide the required heat fluxes and temperatures we plan to use the rather known pyrotechnic composition, whose combustion is described through the given below reaction as follows:

2Fe2O3 + 3Zr = 3ZrO2 + 4Fe + 2840 kJ /kg, (1)

Here specific energy release is given per mass unit of initial PTC. Useful energy release of the reaction (1) is ~900 kJ/kg.

We plan to use only these materials in medium scale experiment. Hereby, a melt will contain two components: 62% ZrO2 + 38%Fe.

2. To provide heat fluxes ~100 kW/m2 into the walls and the bottom of the core-catcher, whose dimensions are given above (Ssurf ~0.25-0.3м2), it is necessary to have energy release inside the melt at combustion of PTC ~50-70 kJ /s (with regard to possible heat losses through a melt surface and heat that goes into concrete destruction and melting). When PTC at a rate of ~0.15-0.2 kg/s of enters a melt the useful specific energy release of PTC will be ~150-180 kJ/kg, i.e. в ~3 times more than it is required.

1. Measuring and diagnostic system

In the course of the experiment we will measure the following parameters:

1. The temperature in various parts of a molten pool, in the walls and the bottom of the core-catcher;

2. Heat fluxes in the walls and the bottom of the core-catcher;

3. Ablation of the walls and the bottom of the core-catcher.

The temperature will be measured using three methods.

- the melt pool temperature will be measured with the help of surface pyrometry;

- the temperature of the walls and the bottom of the core-catcher will be measured using thermocouples embedded in the concrete (~30 thermocouples);

- the temperature of the molten pool will be measured using thermocouples (~3-5), each will be located in a hermetic protecting container/tank made of refractory ceramics based on ZrO2. Each tank will be positioned inside the melt in different parts of the molten pool.

Heat fluxes in the walls and the bottom of the core-catcher will be measured using the same thermocouples that are used for measuring a temperature.

Ablation of the walls and the bottom of the core-catcher can be measured by the help of the same thermocouples that are used for measuring a temperature (as thermocouples destruction).

IV. The large-scale experiment will consist of the following components

1. Development and production of the core-catcher;

2. Development of technology and production of PTC briquettes (Fe2O3+Zr);

1. Development of technology and production of PTC briquettes (Fe2O3+U);
2. Development and production a system to deliver briquettes to the melt;
3. Development of initiation technology for the PTC briquettes;
4. Development and production a measurement system to measure temperature and heat fluxes in concrete using thermocouples;
5. Development and production a measurement system to measure the temperature of the melt by surface pyrometry;
6. Development of technology to cut a solidified bigot of melt after it has cooled down;
7. Metallographic analysis of experimental results;
8. Numerical analysis of experimental results.

Only one of these 10 stages will not be tested in the medium-scale experiment (item 3). Thus, in our opinion, based on the results of the medium-scale that will be carried out without uranium, a decision can be made on the performance of a large-scale experiment with uranium.