# EXPERIMENTAL METHODS AND PROCESSING OF DATA

# MONITORING THE FLOW RATE OF WATER IN THE SUPERCRITICAL CONVECTION LOOP

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The Supercritical Water Convection Loop with an irradiation chamber is created in KIPT. The Loop is made from stainless steel. It measures 1.2 by 1.5 m. The plant makes possible to carry out simulation corrosion tests of potential structural materials for Generation IV reactors with the Supercritical Water-Cooling (SCWR) under irradiation. Specimens in water flow at 350…400°C, 23…25 MPa are irradiated by the 10 MeV/10 kW electron beam of LUE-10 linear accelerator. The monitor with powerful permanent magnets in the turning components is being devised for expeditious control of the flow water velocity.

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## INTRODUCTION

During 2010-2012 years in KIPT the convection loops with supercritical water (Supercritical Water Convection Loop, SCWCL) were developed for researches of influence of accelerated electron cumulative effects and of environment heterophase fluctuations on metals and alloys. The irradiation cells of these loops are connected with linear electron accelerator LUE-10 (10 MeV, 10 kW).

These loops have made the basis of the Canada-Ukraine Electron Irradiation Test Facility (CU-EITF) for testing of the electronic irradiation influence on the corrosion and mechanical properties of the constructional materials used for reactor with cooling by supercritical water (SCWR).

Three SCWCL pilot plants have been developed and made. The all-welded SCWCL with four-channel irradiation cell (in the following Loop1a) and SCWCL with one-channel irradiation cell are made of stainless steel 12X18H10T and folding SCWCL with the circulating pump (in the following Loop2) is made of an alloy of titan VT22. The internal volume of each loop makes approximately 4 litres. The specially developed rotor-type flow monitors were established inside of the Loop1a and Loop2 (Figs. 1-4).

*Fig. 1. Loop1a on the test bed. The arrow specifies a placement of the flow monitor*

## 1. MONITOR DESIGN

In our case the monitor sizes were defined from parameters SCWCL. Internal diameter of loop pipes is equal to 32 mm.

*Fig. 2. An external view of the monitor N1 for the control of the water flow in SCWCL*

The water flow rotates the rotor inside monitor body.

*Fig. 3. Loop2 on the test bed. The arrow specifies a placement of the flow monitor*

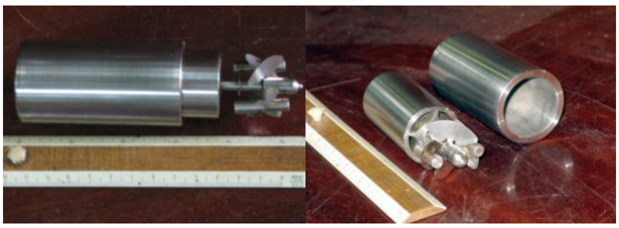

*Fig. 4. An external view of the monitor N2 for the control of the water flow in SCWCL*

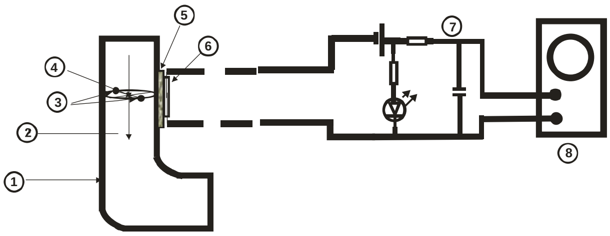


*Fig. 5. The scheme of flow rate experimental measurement: 1 – pipe; 2 – water course; 3 – impeller magnets; 4 – rotating impeller; 5 – heat insulation; 6 – sealed contact; 7 – antijingling RC-chain; 8 – oscillograph*

When the rotor blades supplied by magnets passes by the contactless switch, located on the SCWCL body, it works (Fig. 5).

Internal diameter SCWCL is equal to 32 mm. In view of four channel irradiation cell the effective hydraulic diameter of Loop1a is equal to 26 mm. Expected natural circulation (Fig. 6) in Loop1a is estimated in work [4, 5].

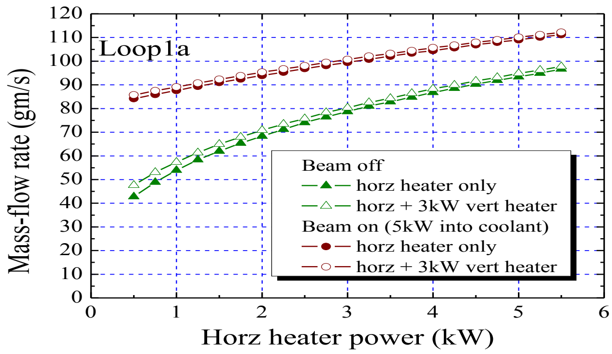


*Fig. 6. Relationship between the water flow and the heating power in Loop1a in near critical condition – (P ≤ 23.5 MPa, T ≤ 380°C)*

In the experiments [2, 3] the water flow rate up to 80 g/s would thus be expected at water density of 0.5 g/cm$^3$ if the total power of an electron beam and heaters was about 5 kW.

## 2. EXPERIMENTAL RESEARCHES

The flow monitor1 was placed on the SCWCL Loop1a in irradiation of the samples of two types: the samples of the Inconel 690 with two-layer In 52MSS wire surfacing and the samples of the alloy Zr. Four sessions of the irradiation [2] have been performed using the electron beam with energy 10 MeV. The samples are irradiated at a pressure of 23.5 MPa, a maximal temperature on the surface irradiation cell below 380°C and the mass flow rate more than 50 g/s. The total session duration was 574 h (including 497 h with the electron beam), the maximum fluence on the irradiation cell surface was $10^{20}$ electron/cm$^2$.

The monitor graduation tests were performed before monitor installation in SCWCL. Tests were spent with the water flow rate in an interval 0…180 g/s. The results of these tests are shown in Figs. 7, 8.

There were not observed the monitor1 signals during performing the irradiation experiments on SCWCL Loop1a. It is possible to assume, that the flow of the natural circulation in the loop did not exceed 70 g/s.

The monitor1 graduation tests were repeated after Loop1a dismantlement from the accelerator bunker. Received graduation dependence was slightly differed from primary. That specifies sufficient safety factor of the construction and the monitor serviceability.

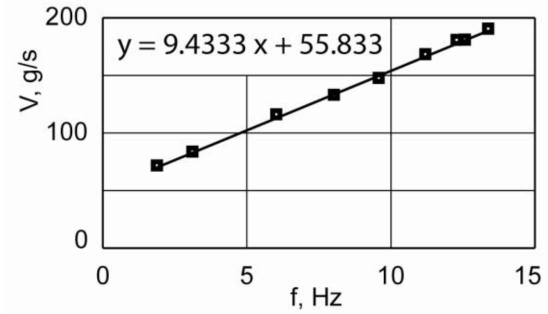


*Fig. 7. The graduation test results of the monitor N1 in the water flow at the 20°C*

Reference to Fig. 7 shows that monitor1 rotor begins to rotate if the water flow rate attains about 70 g/s.

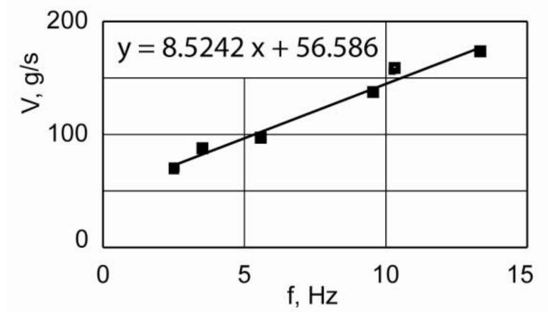


*Fig. 8. The graduation test results of the monitor N2 in the water flow at the 20°C*

## CONCLUSIONS

The developed monitor advantages are simplicity and reliability of the operation in the conditions of powerful ionizing radiation. Therefore it has been used in the experiment on the sample irradiation in SCWCL Loop1a. Absence of signals of the monitor in the given experiment shows that it was not achieved the value of flow liquid rate in the loop needed for monitor work.

The further researches of this monitor during experiments with SCWCL Loop-2 are assumed.

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## МОНИТОРИНГ СКОРОСТИ ПРОТОКА ВОДЫ В СВЕРХКРИТИЧЕСКОЙ КОНВЕКЦИОННОЙ ПЕТЛЕ

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В ХФТИ создана сверхкритическая водяная конвекционная петля с камерой облучения. Петля размером 1,2×1,5 м изготовлена из нержавеющей стали. Установка позволяет проводить коррозионные тесты потенциальных конструкционных материалов реакторов IV поколения сверхкритическим водным охлаждением под облучением. Образцы в потоке воды при 350…400°C, 23…25 МПа облучаются электронным пучком 10 МэВ/10 кВт линейного ускорителя ЛУЭ-10. Приводятся результаты разработки мониторов для контроля скорости потока в сверхкритической водяной петле при облучении исследуемых материалов.

## МОНІТОРИНГ ШВИДКОСТІ ПРОТОКУ ВОДИ У НАДКРИТИЧНІЙ КОНВЕКЦІЙНІЙ ПЕТЛІ

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У ХФТІ створена надкритична водяна конвекційна петля з камерою опромінення. Петля розміром 1,2×1,5 м виготовлена з нержавіючої сталі. Установка дозволяє проводити корозійні тести потенційних конструкційних матеріалів реакторів IV покоління надкритичним водним охолодженням під опроміненням. Зразки в потоці води при 350...400°C, 23...25 МПа опромінюються електронним пучком 10 МеВ/10 кВт лінійного прискорювача ЛПЕ-10. Наводяться результати розробки моніторів для контролю швидкості потоку в надкритичній водяній петлі при опроміненні досліджуваних матеріалів.