REGIMES OF IRRADIATION BY ELECTRONS OF SAMPLES OF MATERIALS IN SUPERCRITICAL WATER CONVECTION LOOP

A.S. Bakai, V.N. Boriskin, M.I. Bratchenko, A.N. Dovbnya, S.V. Dyuldya, Yu.V. Gorenko, V.A. Momot, S.K. Romanovsky, A.N. Savchenko, V.I. Solodovnikov, V.Yu. Titov, S.V. Shelepko, G.N. Tcebenko

National Science Center "Kharkov Institute of Physics and Technology", Kharkov, Ukraine

E-mail: boriskin@kipt.kharkov.ua

The specially designed in the NSC KIPT Supercritical Water Convection Loop (SCWCL) with an irradiation chamber coupled to an electron accelerator LPE-10 gives an opportunity for corrosion and mechanical tests of materials under electron irradiation. Specimens in water flow are irradiated by the 10 MeV/10 kW electron beam of the LPE-10 linear accelerator at 23…25 MPa and 350…400°C. Presented are the irradiation regime parameters for the 500 hours long work session of the SCWCL.

PACS: 07.35.+k, 29.20.Ej, 28.52.Fa

INTRODUCTION

The Supercritical Water-Cooled Reactor (SCWR) is one of the most promising options identified for R&D under the Generation IV (GenIV) program [1]. At the Atomic Energy of Canada Limited (AECL), the it was recognized as the next evolutionary step of CANDU technology and obtained a high priority status [2, 3]. The SCWR relevant R&D are carried out in Korea [4, 5], U.S. [6, 7], Japan [8], Russia [9], and China [10]. Different candidate structural materials are considered for the SCWR: austenitic and ferretic-martensitic (F/M) stainless steels (SS), Ni-, Zr- and Ti-based alloys, and innovative oxide dispersion strengthened (ODS) steels and alloys. Their corrosion rates and stress corrosion cracking (SCC) in pure SCW is studied experimentally using SCW circulation loops (SCWCL) without irradiation.

However, the SCW properties under irradiation are not investigated in detail. The irradiation induced radiolysis impact on the SCW flow control and instabilities, *incl.* the sub- to supercritical state transitions, is of great interest for SCWR R&D, and can also affect the corrosion of materials. This requires thorough studies at dedicated experimental facilities [11] providing combined exposure of samples to both SCW flow and irradiation.

In 2009, the Canadian government provided funding to support the collaborative activities between the NSC KIPT and the AECL Chalk River Laboratories aimed at the development of advanced experimental facilities and methodologies for the assessment of structural materials recognized as promising candidates for SCW reactors. In 2010-2012, the convection loops were specially developed, in KIPT, for *in situ* investigations of combined effect of ionizing irradiation and heterophase fluctuations of the supercritical water (SCW) environment on corrosion, oxidation, and mechanical properties of metals and alloys. The irradiation cell (IC) equipped Supercritical Water Convection Loop (SCWCL) was coupled to the 10 MeV, 10 kW electron accelerator LPE-10 as a basis for the test bench of the Canada-Ukraine Electron Irradiation Test Facility (CU-EITF) for corrosion tests of structural materials of GenIV SCWR [12, 13].

Three SCWCL models were developed and manufactured:

a) the prototype one without an irradiation cell;

b) the all-welded SCWCL with four-channel IC;

c) the dismountable SCWCL with the circulation pump and the IC made from the Ti alloy VT22.

The internal volume of each loop is about 4 liters. The pipes of all the devices (a-c) and the IC of the SCWCL model (b) were made from the 12X18H10T stainless steel. Dimensions of the loops (1.2×1.5 m, Fig. 1) and other component parts of the SCWCLs were essentially determined by the size and arrangement of the KIPT sited bunker room (see Fig. 1) which houses the electron accelerator LPE-10 [14, 15].

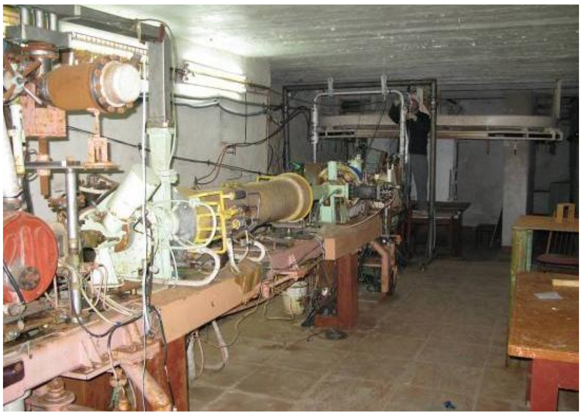


Fig. 1. Placement of the SCWCL in the bunker room of the LPE-10 electron linac

In the present paper, the results of the investigations of the SCWCL Loop-1 and Loop-1a operating modes are presented.

1. REFERENCE DESIGN PARAMETERS

The evaluation of the CU-EITF circulation loop operational parameters was based on the one-dimensional thermal-hydraulic (TH) model [16 - 18] of a single-channel, single-phase natural convection loop. For a steady-state operation of a closed loop of length L, the enthalpy h is a periodical function of pass length x ($h(0) = h(L)$), and the overall pressure drop vanishes:

$$\oint_{\text{loop}} \Delta p(x, w)\mathrm{d}x = 0\,. \qquad (1)$$

The steady-state mass flow rate w is a root of Eq. 1. The computer code solves it for flexible models of circulation loops of segmented structure (Fig. 2). Each i^{th} segment of a loop is characterized by its geometrical parameters (length l_i, slope θ_i, hydraulic diameter D_i), the applied heating/cooling power density $q_i = \pm Q_i$, and the hydrodynamic friction factors. Obviously, the balance of heating and cooling powers $\sum_i q_i l_i S(D_i) = 0$ must be kept to obtain a steady-state solution.

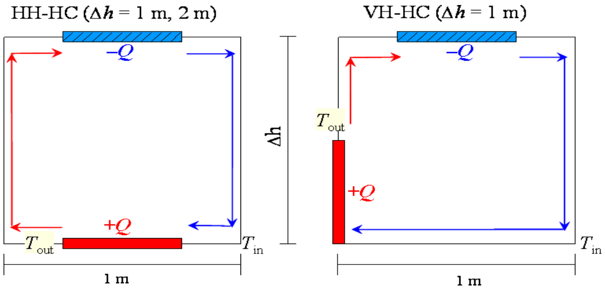


Fig. 2. Typical schemes of natural circulation loops (NCLs) with horizontal heater and cooler (HH-HC) and vertical heater and horizontal cooler (VH-HC)

The following friction model was implemented [16]:

$$C_k(x,w,h)\cdot\Delta x=\frac{f(\mathrm{Re})\cdot\Delta x}{2\cdot D}+\sum_i K_i\cdot\delta(x-x_i)\cdot\Delta x\,, \qquad (2)$$

where $Re = w\cdot D/\mu(h)$ is the Reynolds number of a flow, $\mu(h)$ is the dynamical viscosity of a fluid, the coefficient

$$f(Re)=\max\left(\frac{64}{Re},\frac{0.3164}{Re^{0.25}}\right), \qquad (3)$$

describes dynamical friction in laminar and turbulent flows, and the coefficients K_i are (phenomenological) dimensionless local friction factors (K-factors, or restriction coefficients) of the convection loop segments.

The equation (1) was solved numerically by the iterative calculations and summarization of pressure drops with enthalpy profiles for all segments of a circulation loop until the total pressure drop reduces to a reasonably small value, a tolerance limit of calculation. Then the density, temperature, mass and linear velocity profiles were calculated along all SCWCL segments using the obtained value of the steady-state mass flow rate w.

For the CU-EITF SCWCL reference design, the preliminary TH calculations results were taken into account. They determined a rather conservative choice of the loop piping internal diameter (D = 32 mm) and the electric heater power (Q = 20 kW). The dimensions of the SCWCL were fixed to a width of 1.2 m and a height of 1.5 m. The results of the TH characterization of such a reference design of CU-EITF SCWCL are presented below in this section.

1.1. SUPERCRITICAL OPERATION MODE

An integrated compilation of calculated output characteristics of an expected steady state operation mode of CU-EITF SCWCL is presented in Fig. 3,a-d for a supercritical regime (p = 23 MPa, T_{in} = 650 K) of a loop. The results depicted in this figure are self-descriptive, and are not discussed here in detail. Let's emphasize major conclusions that follow from these calculations:

- the acceptable mass (~50…100 gm/s, see Fig. 3,a) and linear (up to 1 m/s, see Fig. 3,b) rates of SCW natural convection flow are obtainable;
- the loop overheat is prevented (see Fig. 3,c) in a wide range of heater power Q and up to large ($K > 300$) values of the SCWCL legs effective K-factor;
- the characteristic SCW temperatures T_{out} at the entrance of irradiation cell are close to the inlet temperature;
- the characteristic densities of SCW entering the irradiation cell (see Fig. 3,d) are of order of 0.3 gm/cc at reasonable local friction factors $K \sim (10…100)$, and $Q < 30$ kW.

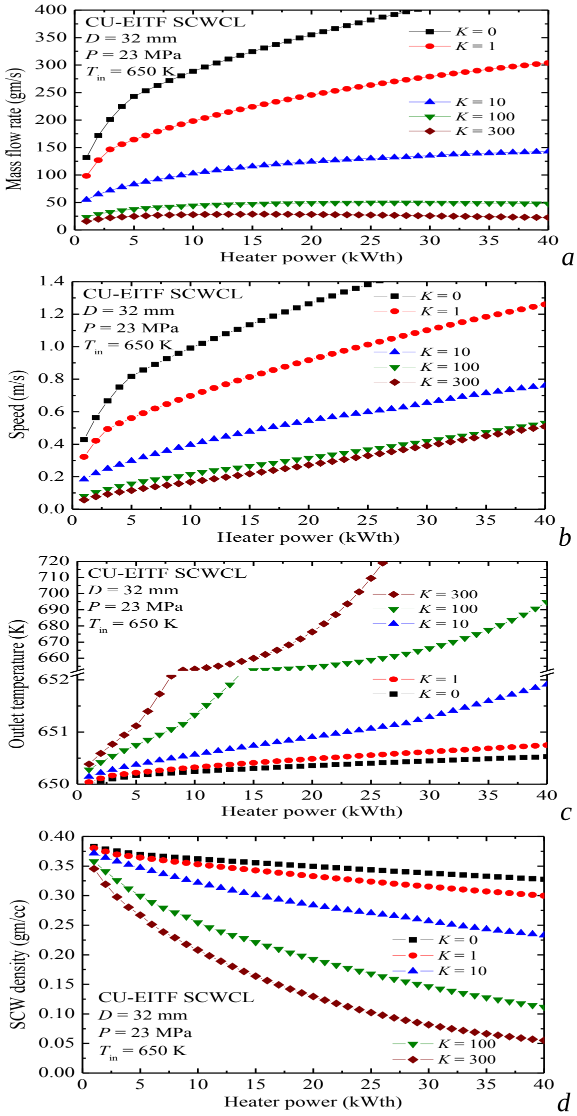


Fig. 3. Heater power Q dependencies of W (a), v (b), T_{out} (c) and ρ_{out} (d) for the reference configuration CU-EITF SCWCL operating in a supercritical mode (23 MPa, 650 K)

1.2. IMPACT OF *e*-BEAM ON THE CU-EITF SCWCL STEADY STATE REGIME

The calculations above describe an "idle" mode of a SCWCL operation without irradiation when all power input Q is due to an electric heater. Though valuable experiments on the SCW flow dynamics and materials corrosion can be conducted in this mode, too, of great interest is the impact of the accelerator *e*-beam (EB) irradiation supplied power on the SCWCL TH parameters. This section deals with the TH effects caused by a loop extra heating by a EB irradiation power deposition.

This occurs in the 180 mm long IC positioned at the vertical leg of the loop. It was introduced into the TH model as an additional heater segment of this length starting at a distance 22.1 cm from the bottom pipe level. The reduced hydraulic diameter D_{IC} = 26 mm of this segment (that is due to the presence of the IC internals), has been calculated from the SCW filled free volume of irradiation cell, and used in TH modeling.

At calculations, a conservative assumption had been made that the total nominal power of the KIPT linac *e*-beam (7 kW) is spent to the SCW heating. Obviously, it is a rather strong assumption that, however, will show the amplitude of the expected effect.

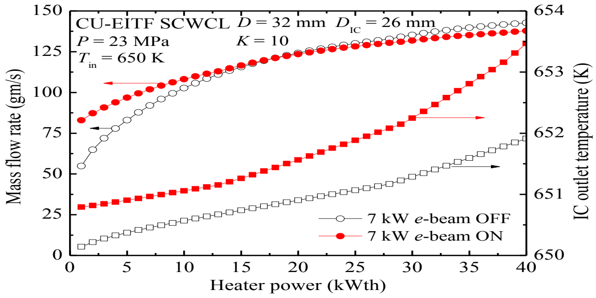


Fig. 4. Heater power Q dependencies of W and T_{out} without (open markers) and with (bold markers) extra heating of the CU-EITF SCWCL irradiation cell by 7 kW electron beam

The results of calculations are shown in Fig. 4 as functions of a power Q of the SCWCL conventional horizontal electric heater. One can see that qualitatively the loop behavior is not affected by the introduction of irradiation induced extra heating though certain quantitative effects are definitely observed.

1.3. SUBCRITICAL OPERATION MODE

The reference CU-EITF SCWCL model has also been applied to the evaluation of subcritical operation of the facility. The conditions $p = 9.9$ MPa, $T_{in} = 533$ K (350°C) were chosen to simulate characteristics of coolant environment of reactors of CANDU family.

The basic TH model (1) - (3) is of limited use for detailed calculations at subcritical conditions since it is intrinsically a single-phase model. However, it can circumscribe the domain in a parameter space where unwanted effects of a flow boiling are suppressed.

The model was tuned to the above mentioned subcritical initial conditions. The results of calculations are presented in Fig. 5 for both idle and *e*-beam powered cases of the facility operation. One can see in Fig. 5,a that the subcritical regime characteristic values of the mass flow rate $w = 50…200$ gm/s are of the same order of magnitude (or greater) then that of in a mainstream supercritical mode. The major constraint arises from the fact that at gradual increase of power Q the outlet temperature can reach a water saturation temperature T_s at 9.9 MPa (see Fig. 5,a). Therefore, the subcritical experiments have to be conducted either at a reduced power or at a special attention paid to the local hydraulic resistance of a loop components.

Fig. 5 shows that at subcritical experiments kept inside the single-phase domain, the SCWCL operates with the same mass flow rates $w \sim 50…100$ gm/s that are expected for the supercritical operation mode.

2. EXPERIMENTAL

2.1. LOOP-1

The SS 12X18H10T made SCWCL prototype measuring 1220×1550 mm (Fig. 6,b) was developed and manufactured for preliminary tests on the experimental stand without irradiation. The internal diameter of the loop piping was 32 mm, the external one was 40 mm. The prototype had two 820 mm long main coolers and two auxiliary coolers which were mounted on branch pipes with measuring manifolds. The water was supplied to the coolers from general pipelines that deliver it to the accelerators cooling systems. The coolant pressure was up to 4 atmospheres, the volumetric flow was up to 12 liters per minute. The water temperature in the mains was 15…35ºC depending on the season.

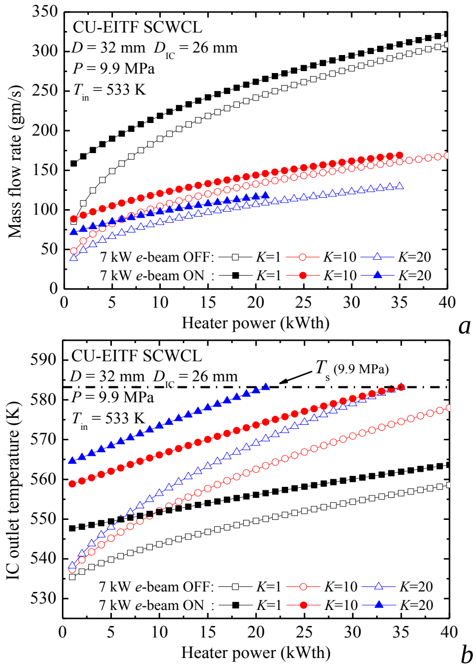


Fig. 5. Q-dependencies of W (a) and T_{out} (b) for a subcritical regime of CU-EITF SCWCL

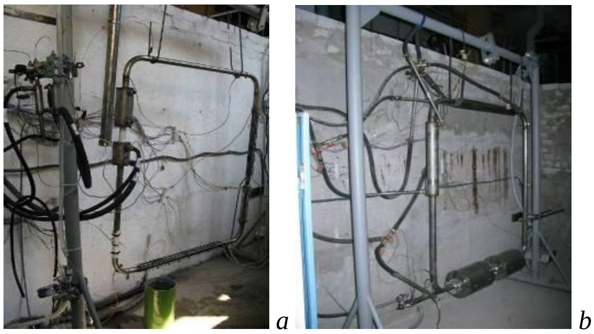


Fig. 6. The SCWCLs Loop-1a with cup-type heaters (a) and Loop-1 (b) with radiative heaters on the test stand

Fig. 7. Cup-type (0.4 kW, 100 mm working length) heater (a) and radiation-type (up to 10 kW, 310 mm internal working length) heaters with silit heating elements (b)

The SS made heaters with silit elements (Fig. 7,b) were developed and manufactured for the prototype. The total power of one block of heaters was up to 10 kW. The work temperature inside the heater was up to 1100ºC.

In total, 15 experimental "hot sessions" of operation were conducted with total duration of 70 hr (*incl.* 12 hr with water in the supercritical conditions). The water pressure amounted to 30 MPa. The loop surface temperature did not exceeded 430ºC. At the same time, it reached 1100ºC under the heaters.

During the experiments, the power rack and the control rack worked *in-line* with the computer. The results of one of the work sessions are presented at Figs. 8, 9. During this session, the loop prototype and heaters were wrapped with 30 mm thick basalt fiber and Al foil to decrease thermal losses. Big coolers were not used. The heaters power, water flow to the small coolers and water drain from the emergency valve were registered and controlled by the operator with the aid of a computer.

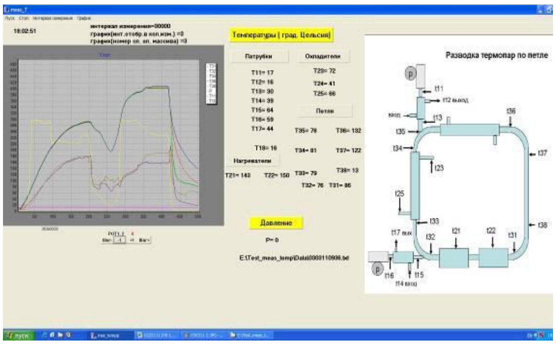


Fig. 8. Videogram from the PC screen of CU-EITF operator during the SCWCL prototype test

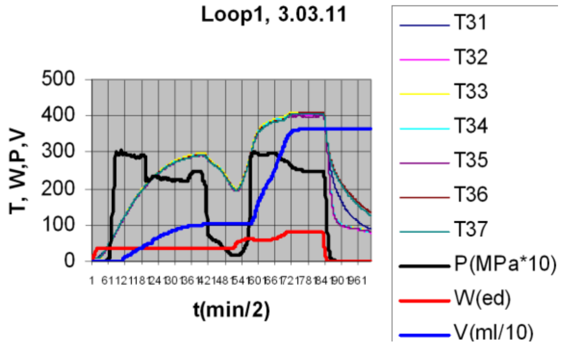


Fig. 9. Temperature, pressure, electric power, and water volume changes plots during the SCWCL prototype test session

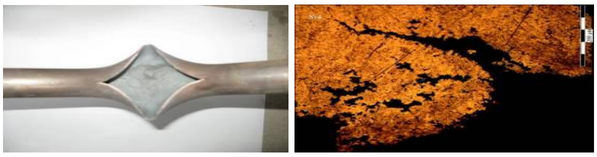
The plots of the electric power (*W*) changes (in relative units), the temperatures at the loop surface (*T*), the water pressure in the loop (*P*), and the volume (*V*) of water passed through the valve are shown in Fig. 9. The values of *W* gradually increased from 5 kW at the beginning of the session, and then up to 15.5 kW.

The loop surface temperature *T* incidentally increased up to 410°C while the temperature inside the heaters reached 1049°C. Up to 3660 ml of water out of 4210 ml has flown out from the loop through the emergency valve (see the plot of *V*) due to thermal expansion.

The pressure in the loop was 25 MPa. At 15.5 kW electrical power, the thermal balance in the loop was achieved at an average loop surface temperature 404°C while the temperature difference at loop surface reached 11…12 K. The small water coolers picked out total power reached ≈7 kW. The upper cooler took off 3 kW (water flow 10.6 kg/min, temperature difference 4°C). The lower cooler picked out 2.4 kW (water flow 11.2 kg/min, temperature difference 3°C). The other remained power losses were up to 1.5 kW.

Basing on these data, the water mass flow rate in the loop during this session was 60 g/s. At the loop sectional area of about 8 cm^2, we obtained the flow linear velocity of about 52 cm/s.

During the last session, the strength limit in the part of the loop prototype under one of the heaters was exceeded. This resulted in the rupture of the loop horizontal part (Fig. 10), and the damage of the heater.



a *b*

Fig. 10. Top view at the point of rupture of the SCWCL prototype pipe (a) and the ×200 magnification cross section electron microscopy along the specimen break

In Fig. 10,b, the cracks penetrating inside the pipe metal to the substantial depth up to 500 μm are clearly seen. The considerable thinning of the pipe wall thickness in the vicinity and in the places of the break argued about the exceed of the tensile stresses of a material over the yield stress limit and testifies that the damage occurred is because of material operational conditions.

3.2. LOOP-1a

The design of the loops with irradiation chambers (see Fig. 6,a) was developed basing on the information obtained during these tests of the prototype. In order to strengthen the construction, the lower horizontal part of the loop with fastened heaters was made of the 40 mm external diameter pipes having a 6 mm thick wall. The sizes of the main coolers were decreased.

The connection of the SCWCL to the chemical analysis mains was arranged through the 10 mm diameter manifolds and fitting joints. The manifolds were welded into the loop near the top left and bottom left corners (see Fig. 6,a). The sensor was implemented into the loop for the water flow rate control [19].

3.3. TESTS OF THE CU-EITF OPERATION MODES UNDER 10 MeV *e*-IRRADIATION

SCWCL “Loop 1a” was mounted in the LPE-10 accelerator bunker for specimen irradiation (Fig. 11) monitored by the video camera and the control systems of the CU-EITF and LPE-10 [17 - 19].

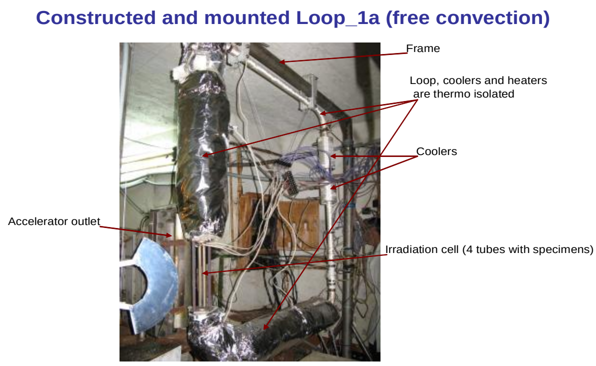


Fig. 11. SCWCL “Loop-1a” during mounting in the LPE-10 accelerator bunker

Four sessions of irradiation of samples by the 10…11 MeV EB were conducted at the LPE-10 linac. The EB mean current was 0.5…0.8 mA (Fig. 12). The EB pulse frequency was 250 Hz at the pulse duration 3.4 μs and the beam irradiation cell scanning frequency of 3.5 Hz. The average vertical span of the beam in the irradiation cell plane was 21 cm (Fig. 11).

The total duration of sessions was 572 h including 497 h under the beam. The maximum fluence on the irradiation cell surface was more than 10^{20} e/cm^2.

The EB parameters were controlled by the LPE operator (see Fig. 12) and were archived (see Fig. 13).

The photometry of electron flux density in the irradiation cell zone was made before the sessions, and is shown in Fig. 14.

The operating conditions for SCWCL "Loop-1a" were: the pressure 23.5 MPa, the maximum temperature at the IC surface up to 380ºC (see Figs. 9-11). The simulation estimated mass flow rate was 70…80 g/s. Correspondingly, the linear velocity of subcritical water in the IC cartridges was ~0.5 m/s. The parameters of "Loop-1a" were controlled by the session operator (Fig. 15) and saved to the archive (Figs. 16, 17).

Fig. 12. The display of the LPE-10 operator's control panel

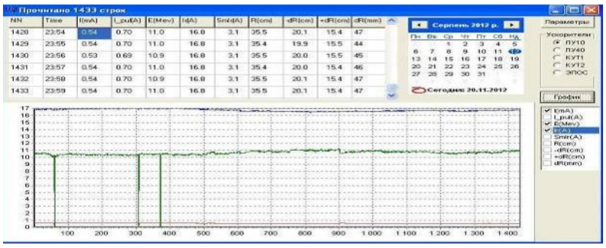


Fig. 13. LPE-10 parameters archive. Information on 12.08.2012

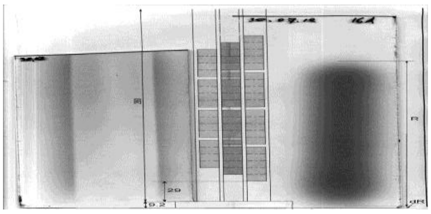


Fig. 14. Glass photometry of the e-beam (30.07.2012). The glass (S3) is behind the irradiation cell on the left and in front of the cell – on the right (S2). The layout of samples in the cell is in the middle

CONCLUSIONS

The stable subcritical and supercritical operating modes of two options of the 1.2×1.5 m 4 litre water convection loop volume were substantiated by calculations and confirmed experimentally. It is experimentally shown that with adequate external thermal insulation of the loops the external heaters with capacity of 6…15 kW are enough for the transition of the convection water loops in the supercritical mode operation.

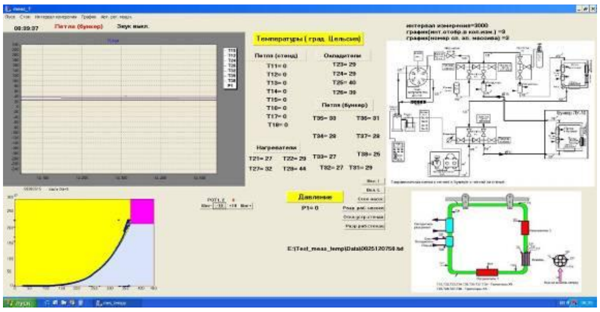
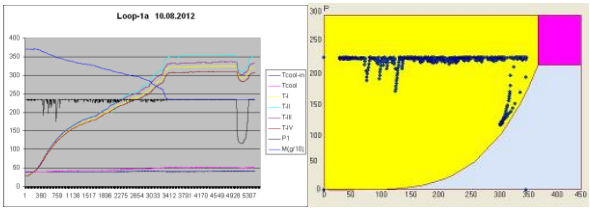
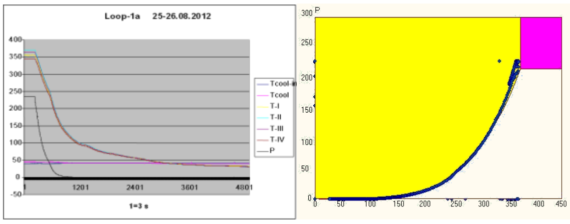


Fig. 15. The display on the CU-EITF operator's control panel. The cooling of the loop at the end of the session



a *b*

Fig. 16. The irradiation cell, T and cooler, Tcool, temperature curves (°C), *the curves of water pressure P* (bar) *and mass M in the loop (a) and the consoleplot (b) at the beginning of irradiation mode (10.08.2012)*



a *b*

Fig. 17. The irradiation cell, T and cooler, Tcool, temperature curves (°C) *and the curve of water pressure P (bar) and mass M in the loop (a) and the console P/(T-II) plot (b) at the ending of irradiation (26.08.2012)*

REFERENCES

1. U.S. DOE nuclear energy research advisory committee and the Generation IV international forum // *A Technology Roadmap for Generation IV Nuclear Energy Systems*. GIF-002-00, (December 2002).
2. R.B. Duffey, H.F. Khartabil, I.L. Pioro, J.M. Hopwood. *The future of nuclear: SCWR Generation IV high performance channels // Proc. of the 11th Int. Conf. on Nucl. Eng.* (ICONE-11), Shinjuku, Tokyo, Japan, April 20-23, 2003. Paper № 36222, 8 p.
3. K.P. Boyle, D. Brady, D. Guzonas, H. Khartabil, et al. Canada's Generation IV national program – overview // *Proc. of the 4th Int. Symp. on SCWRs*, March 8-11, 2009, Heidelberg, Germany. Paper № 74, 13 p.
4. Y.-Y. Bae, J. Jang, H.-Y. Kim, H.-Y. Yoon, H.-O. Kang, K.-M. Bae. Research activities on a supercritical pressure water reactor in Korea // *Nucl. Eng. Tech.* 2007, v. 39, № 4, p. 273-286.
5. S.-Y. Hong, K. Lee, S.-M. Bae, Y.-B. Kim, et al. Interim results of SCWR development feasibility study in Korea // *Proc. of the 4th Int. Symp. on SCWRs*, March 8-11, 2009, Heidelberg, Germany. Paper № 50, 6 p.

6. G.S. Was, P. Ampornrat, G. Gupta, S. Teysseyre, E.A. West, T.R. Allen, et al. Corrosion and stress corrosion cracking in supercritical water // *JNM*. 2007, v. 371, p. 176-201.
7. M.H. Anderson, J.R. Licht, M.L. Corradini. Progress on the University of Wisconsin super-critical water heat transfer facility // *Proc. of the 11th Int. Topical Meeting on Nuclear Reactor Thermal-Hydraulics* (NURETH 11), Avignon, France, October 2-6, 2005, paper № 265.
8. Y. Ishiwatari, Y. Oka, K. Yamada. Japanese R&D projects on pressure-vessel type SCWR // *Proc. of the 4th Int. Symp. on SCWRs*, March 8-11, 2009, Heidelberg, Germany, Paper № 73, 9 p.
9. Yu.D. Barnayev, P.L. Kirillov, V.M. Poplavskij, V.N. Sharapov. Nuclear reactors based on super-critical pressure water // *Atomic energy*. 2004, v. 96, № 5, p. 374-380.
10. X. Cheng. R&D activities on SCWR in China // *Proc. of the 4th Int. Symp. on SCWRs*, March 8-11, 2009, Heidelberg, Germany. Paper № 53, 14 p.
11. P. Hajek, R. Vsolak, M. Ruzickova. First experience with operating the supercritical water loop // *Proc. of the 4th Int. Symp. on SCWRs*, March 8-11, 2009, Heidelberg, Germany. Paper № 69, 10 p.
12. A.S. Bakai, V.N. Boriskin, A.N. Dovbnya, S.V. Dyuldya, D.A. Guzonas. Supercritical water convection loop (NSC KIPT) for materials assessment for the next generation reactors *// Proc. of the 5th Int. Symp. on SCWRs*. Vancouver, BC, Canada, March 13-16, 2011, Paper № 51.
13. A.S. Bakai, V.N. Boriskin, M.I. Bratchenko, E.Z. Biller, P.A. Bytenko, V.A. Bocharov, V.N. Vereshchaka, A.N. Dovbnya, S.V. Dyuldya, Yu.V. Gorenko, G.G. Kovalev, V.A. Momot, O.A. Repihov, S.K. Romanovsky, A.N. Savchenko, V.V. Selezn’ev, V.I. Solodovnikov, V.I. Titov, A.V. Torgovkin, V.V. Handak, S.V. Shelepko, G.N. Tcebenko. Electron irradiation of the material samples of new generation nuclear reactors in the supercritical water convection loop // *Problems of Atomic Sci. and Tech. Ser. “Nucl. Phys. Investigations”*. 2013, № 6(88), p. 230-234.
14. A.N. Dovbnya, M.I. Ayzatsky, V.N. Boriskin, et al. Electron Linacs Based Radiation Facilities of Ukrainian National Science Centre KIPT // *Bull. Am. Phys. Soc.* 1997, v. 42, № 3, p. 1391.
15. M.I. Ayzatsky, V.N. Boriskin, A.M. Dovbnya, et al. The NSC KIPT Electron Linacs R&D // *Problems of Atomic Sci. and Tech. Ser. “Nucl. Phys. Investigations”*. 2003, № 2(41), p. 19-24.
16. *Natural circulation data and methods for advanced water cooled nuclear power plant designs* IAEA-TECDOC-1281, IAEA, Vienna, 2002, 252 p.
17. *Natural circulation in water cooled nuclear power plants: Phenomena, models, and methodology for system reliability assessments*. IAEA-TECDOC-1474, IAEA, Vienna, 2005, 649 p.
18. M. Sharmaa, D.S. Pilkhwal, P.K. Vijayan, D. Saha, R.K. Sinha. Steady state and linear stability analysis of a supercritical water natural circulation loop // *Nucl. Eng. Design*. 2010, v. 240, p. 588-597.
19. A.S. Bakai, E.Z. Biller, A.M. Bovda, V.N. Boriskin, Yu.V. Gorenko, V.A. Momot, L.V. Onischenko, V.I. Solodovnikov, S.V. Shelepko. Monitoring the flow rate of water in the Supercritical Convection Loop // *Problems of Atomic Sci. and Tech. Ser. “Nucl. Phys. Investigations”.* 2016, № 3(103), p. 120-122.

Article received 31.10.2017

РЕЖИМЫ ОБЛУЧЕНИЯ ЭЛЕКТРОНАМИ ОБРАЗЦОВ МАТЕРИАЛОВ В СВЕРХКРИТИЧЕСКОЙ ВОДЯНОЙ КОНВЕКЦИОННОЙ ПЕТЛЕ

А.С. Бакай, В.Н. Борискин, М.И. Братченко, А.Н. Довбня, С.В. Дюльдя, Ю.В. Горенко, В.А. Момот, С.К. Романовский, А.Н. Савченко, В.И. Солодовников, В.Ю. Титов, С.В. Шелепко, Г.Н. Цебенко

Специально разработанная в ХФТИ сверхкритическая водяная конвекционная петля (СВКП) с камерой облучения, связанная с ускорителем электронов ЛУЭ-10, позволяет проводить коррозийные тесты потенциальных конструктивных материалов реакторов IV поколения со сверхкритическим водяным охлаждением (SCWR) 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 параметры режимов облучения образцов во время 500-часового сеанса работы СВКП.

РЕЖИМИ ОПРОМІНЕННЯ ЕЛЕКТРОНАМИ ЗРАЗКІВ МАТЕРІАЛІВ У НАДКРИТИЧНІЙ ВОДЯНІЙ КОНВЕКЦІЙНІЙ ПЕТЛІ

О.С. Бакай, В.М. Борискін, М.І. Братченко, А.М. Довбня, С.В. Дюльдя, Ю.В. Горенко, В.О. Момот, С.К. Романовський, А.М. Савченко, В.І. Солодовников, В.Ю. Титов, С.В. Шелепко, Г.Н. Цебенко

Спеціально розроблена в ХФТІ надкритична водяна конвекційна петля (НВКП) з камерою опромінення, яка зв’язана з прискорювачем електронів ЛПЕ-10, дозволяє проводити корозійні тести потенційних конструкційних матеріалів реакторів IV покоління з надкритичним водяним охолодженням (SCWR) під опроміненням. Зразки в потоці води при 350…400°C, 23…25 МПа опромінюються 10 МеВ/10 кВт електронним пучком лінійного прискорювача ЛПЕ-10. Приводяться параметри режимів опромінення зразків під час 500-годинного сеансу роботи НВКП.