On the sample 1 in the point −103 mm lower the centre of active core the fast neutron fluence with energy above 0.8 MeV is equal to $(2.6 \pm 0.4) \cdot 10^{22}$ n/cm^2. On the sample 2 in the point +103 mm above the centre of active core - $(2.5 \pm 0.4) \cdot 10^{22}$ n/cm^2.

In conclusion the authors sincerely thank V.N.Khamov for the preparation and carrying out of the radiations. W.S.Sergejeva and T.Ph.Pjankova for samples handling.

REFERENCES

1. *Tyryshkin V.M., Yuzgin V.S.* //AE, 1977. V.43. S.4. P.289.
2. *Vasiljeva T.I., Isakas I.E., Konoplev K.A..* Preprint LNPI-874. Leningrad. 1983. 29 p.
3. *Vasiljev G.Ja., Egodurov S.D., Tchmshkyan D.V.* //Method and technics of reactor and postreactor experiments in radiation materials learning. Theses of reports, SRTAR, Dimitrovgrad, 1983. P.21.

NEUTRON IRRADIATION INFLUENCE ON CAB-1 ALLOY MECHANICAL PROPERTIES

G. Ja. Vasiliev, V. I. Didenko, K. A. Konoplev, V. L. Solovey, D. V. Tchmshkyan, B. A. Gromov[1], A. N. Lapin, V. V. Rybin[2], A. V. Kozlov[3], B. S. Rodtchenko[3], V. K. Shamardin[4]

[1] *VIAM, Moscow*
[2] *CSRI KM "Prometey", St.Petersburg*
[3] *SD RDIPE, Ekaterinburg*
[4] *CSC SRIAR, Dimitrovgrad*

In the present paper was investigated CAB-1 alloy mechanical properties in dependence of the fast neutron fluence by temperature from −196 to +120°C.

For the testing standard samples at tensile strength with diameter working part 3 mm irradiated in the active core of the WWR-M reactor and in DEK channel of the SM-2 reactor was used. Besides the samples making from ampoule legs and control and protection system (CPS) channel irradiated in the WWR-M reactor within 25 and 22 years accordingly were tested.

CAB-1 alloy had standard heat treatment – hardening at temperature 520°C and natural ageing at 20°C during 7 days. CAB-1 alloy chemical composition is presented in Table 1.

Fast neutron fluence on the samples in ampoules was determined by calculating experimental method by activation of companied detectors. At the samples created from legs fast neutron fluence was determined from measurements of fast neutron flux density in the legs and from irradiation history analysis. The error of fast neutron fluence measurements was 15%. The ratio of thermal neutron flux density to fast neutron flux density with energy above 0.1 MeV $\Phi_{th}/\Phi_{0.1}$ was equal to 2 in the middle plane of the active core of WWR-M reactor, to 6 – on upper level of lattice and to 10 – on lower level of lattice.

Calculated temperature of the samples exposured in the active core WWR-M reactor and leges don't exceed 65°C. Exposure temperature in the channel DEK of the SM-2 reactor was equal to $75 \div 25$°C.

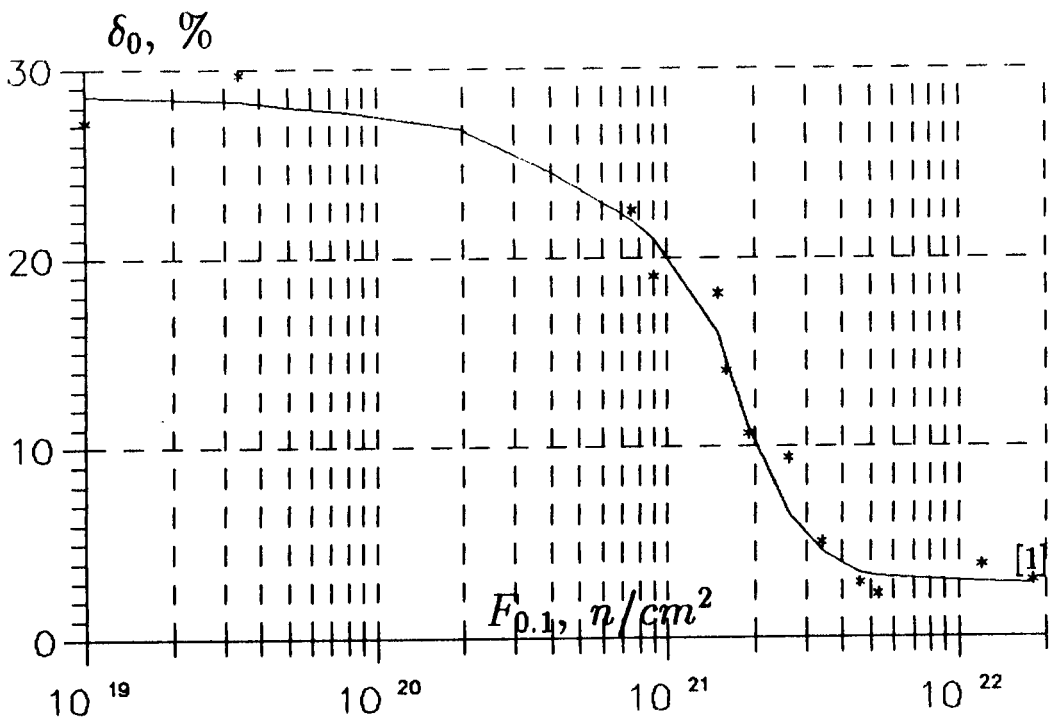

Fig. The δ_0 dependence from the fast neutron fluence with energy above 0.1 MeV at tests temperature 20°C

Table 1

CAB-1 alloy chemical composition

Alloy type	Chemical composition, %								Comments
	Si	Mg	Cu	Fe	Zn	Ni	Mn	Al	
CAB-1	0.7 ÷ 1.2	0.45 ÷ 0.9	0.01	0.2	0.03	0.03	0.06	Balance	by TC
CAB-1	1.2	0.33	0.004				0.002	Balance	Leg 2
CAB-1	0.85	0.66	0.002	0.16				Balance	Samples VIAM

Table 2

Cab-1 alloy mechanical properties changing depending on neutron fluence and testing temperature

$F_{0.1}$ n/cm^2	N_{dpa} dpa	T_{test} °C	$\sigma_{0.2}$ kG/mm^2	σ_B kG/mm^2	δ_P %	δ_0 %	Ψ_K	Comments
0	0	-196	21.8 ± 0.2	35.8 ± 1.1	19.3 ± 0.6	19.3 ± 0.6	11 ± 4	
		20	15.8 ± 0.4	25.8 ± 0.5	17.7 ± 1.2	27.2 ± 1.3	48 ± 7	
		60	14.9 ± 1.3	24.4 ± 1.8	18.0 ± 0.8	27.0 ± 1.3	55 ± 7	
		95	15.2 ± 0.2	23.0 ± 0.2	15.5 ± 1.0	26.5 ± 1.0	54 ± 7	
		100	15.6 ± 1.4	23.4 ± 2.1	12.6 ± 3.4	27.6 ± 4.1	60 ± 4	
		120	14.8 ± 0.4	21.2 ± 0.3	14.5 ± 1.0	25.8 ± 3.5	57 ± 7	
$3.4 \cdot 10^{19}$	0.032	-196	25.0 ± 0.4	37.1 ± 1.1	15.6 ± 1.2	16.0 ± 1.3	23 ± 7	Tested in SD RDIPE
		20	19.2 ± 0.5	28.0 ± 0.3	19.0 ± 1.0	29.7 ± 1.3	53 ± 6	
		100	16.4 ± 0.2	23.8 ± 0.4	14.9 ± 0.3	29.3 ± 2.0	63 ± 5	
$7.6 \cdot 10^{20}$	0.68	-196	31.5 ± 0.4	39.6 ± 0.7	11.1 ± 0.4	11.1 ± 0.4	14 ± 4	
		20	24.1 ± 0.8	32.3 ± 0.6	16.1 ± 1.5	22.5 ± 1.5	29 ± 2	
		100	22.1 ± 1.1	27.9 ± 1.5	12.0 ± 2.3	24.1 ± 9.0	35 ± 7	
$1.5 \cdot 10^{21}$	1.35	-196	29.1 ± 1.7	37.9 ± 1.0	9.1 ± 0.4	9.1 ± 0.4	18 ± 7	Tested in CSRI KM Prometey
		20	22.8 ± 0.2	32.8 ± 0.6	15.1 ± 1.1	18.1 ± 1.5	34 ± 7	
		60	21.8 ± 2.1	28.6 ± 2.0	15.3 ± 0.7	20.7 ± 1.4	47 ± 7	
		95	19.4 ± 1.1	23.9 ± 1.1	11.2 ± 1.5	16.4 ± 2.7	47 ± 7	
		120	17.2 ± 1.4	21.5 ± 1.0	9.6 ± 0.4	13.9 ± 1.1	22 ± 7	
$0.9 \cdot 10^{21}$	0.81	20	21.5	29.5	16.0	19.0	44	Leg 1 of Be SS *
$1.6 \cdot 10^{21}$	1.44	20	24.5	32.0	11.0	14.0	47	
$2.6 \cdot 10^{21}$	2.34	20	30.0	35.5	7.3	9.4	19	
$4.6 \cdot 10^{21}$	4.14	20	32.0	34.5	2.5	2.9	21	
$1.9 \cdot 10^{21}$	1.7	20	21.9	31.3	10.7	10.7	13	Leg 2 of CPS
$3.4 \cdot 10^{21}$	3.1	20	26.6	33.9	5.0	5.0	10	
$5.3 \cdot 10^{21}$	4.8	20	30.2	35.0	2.3	2.3		T_{irrad} 25 ÷ 75°C
$1.2 \cdot 10^{22}$	11.0	20	30.6 ± 1.9	36.3 ± 1.2	3.8 ± 0.8	3.8 ± 0.8		

* SS — serveillance specimens

Samples testings were created in the CSRI KM"Prometey", SD RDIPE and CSC SRIAR "hot" cells. Samples were tested at ephemeral tensile with velocity of gripping movement $1 \div 3$ mm/min at temperatures - 196, 20, 60, 95, 100 and 120°C.

Main research results CAB-1 alloy mechanical properties changing (yield strength $\sigma_{0.2}$, ultimate strength σ_B, uniform elongation δ_P and general elongation δ_0) depending on neutron fluence and testing temperature are given in Table 2.

At the Fig. the δ_0 dependence from the fast neutron fluence with energy above 0.1 MeV at tests temperature 20°C is given. For the comparison at the Fig. there are presented the data from the work [1] which are coincidenced with our data within error limits of measurements. With changing $F_{0.1}$ from $3.4 \cdot 10^{19}$ n/cm^2 to $5.3 \cdot 10^{21}$ n/cm^2 δ_0 decreases from 29.7% to 2.3%. At samples irradiated in the SM-2 reactor by fluence $1.2 \cdot 10^{22}$ n/cm^2 $\delta_0 = 3.8 \pm 0.8$ was received δ_0 increasing was possibly stipulated by more higher exposure temperature. At all testing samples the brittle failure was not observed.

Obtained data were used for the work resources determination WWR-M reactor vessel, It's necessary CAB-1 alloy radiation embrittlement investigations to carry on at more higher neutron fluence (10^{22} n/cm^2 and above) with enlistment statistics and dynamics investigations of cutting slightly samples with cracks.

REFERENCES

1. *Karasjov V.S. et al.*, //VANT, series "Physics of radiation damages and radiation material learning". 1989. Part 2(49). P.39

TOPAZ COLOURING CHANGE IN WWR-M REACTOR

K. A. Konoplev, S. Ju. Lasakova, S. P. Orlov, D. V. Tchmshkyan, G. Ja. Vasiliev

Introduction

Radiation colouring of the precious stones [1] is due to the formation of radiation damage and due to the change of electron structure of crystals. In nuclear reactor radiation damage is caused by crystal atoms displacement by means of fast neutrons; γ and β - radiation creates in crystals free conduction electrons and holes which are taken by crystal damage. As a result new stripes appear in absorbtion spectrum and crystal colouring changes.

The dependence of topaz colouring change effect from obtained radiation doze necessary for predicting radiation colouring effect was investigated in the present paper.

Radiation conditions for topaz irradiation necessary for defining optimum conditions of topaz radiation colouring in WWR-M reactor was also investigated.

Fast and thermal neutrons fluences were measured by activation method [2]. Thermal and fast neutrons flux dencities were calculated by MCU code [3], and damage doze in N_{dpa} units was calculated by TAY code [4].