

**“DEVELOPMENT OF TECHNOLOGY OF NON-DESTRUCTIVE CONTROL, REPAIR AND
DEFENCE OF METAL OF TUBES OF CONDENSERS OF TG K-1000-60/1500-2 (2M)
“ZAPOROZHSKAJA NPP”.**

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Steamgenerator (SG) PGV-1000M type is intended for making of the saturated steam in power unit with water-water nuclear power-reactor and is the component of circulation loops of the reactor setting.

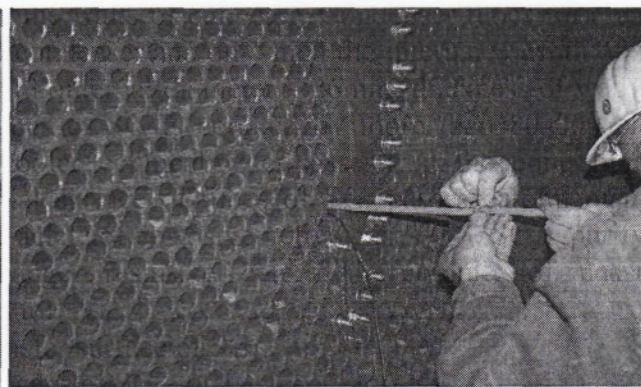
During work of turbine the steam-heatcarrier of the 1st contour is condensed in SG on the horizontally located heat-exchange tubes (HET), fastened in the walls of collector. Condenser tubes form a cooling surface which divides steam and aquatic parts of condenser and on which the internal warmth of steam is passed to circulation water. Length of tubes – 14m, internal diameter – 26mm, thickness of wall – 1mm, material - MNZH-5. The bunch of coolings tubes of SG is counted by more than 80 000 elements, through each of them in the process of work the cooler-technical water passes from the pond. In the same time steam which is condensing on the external surface of tubes of SG, passes careful manystaged preparation further. A runback is refined for the delete of corrosive-active gases (O₂, SO₂), purify from ferromagnetic particles, remove salts by ionchange resins, et cetera The complex of measures on providing of the water-chemical mode must leads to:

- minimizing of of deposits on the heattransfer surface of SG,
- prevention of corrosive and erosive damages of SG,
- minimumizing volume of upcasts, containing harmful for the environment admixture.

And all these considerable efforts on providing of the water-chemical mode appear vain as a result of violation of impermeability of heat-exchange tubes. Thin-walled tubes from copper-nickeliferous alloy easily damaged during exploitation as a result of corrosion and erosion (fig.1)



(fig.1)



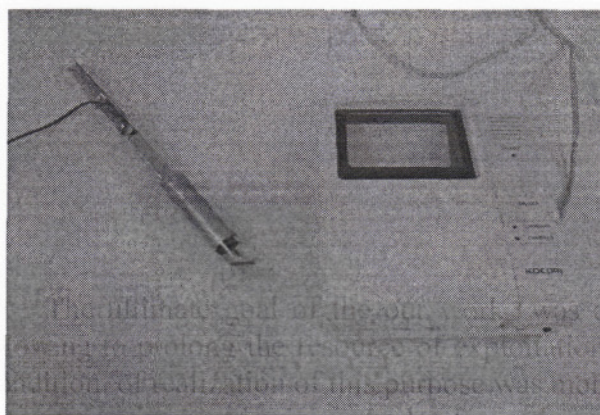
(fig. 2)

and the “bouquet” of admixtures from cooling technical water, gets in a runback. An exit from this situation is found by put out of action of imperfect tubes (their entrance and output is muffled on pipe boards (fig.2). This temporary measure allows to improve quality of runback, but worsens thermophysical descriptions of SG. And there is a limit of amount of the muffled tubes, higher than which exploitation of SG becomes noneffective.

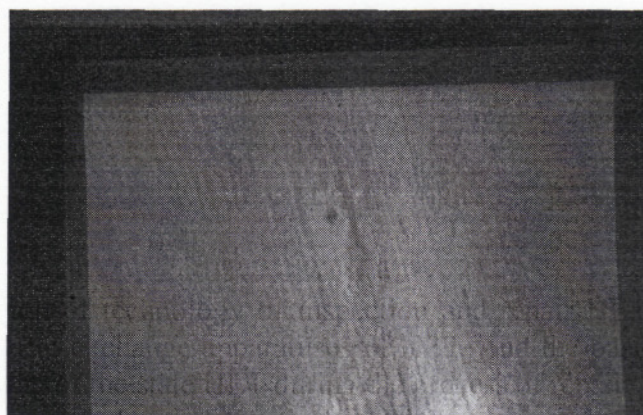
In this connection we are execute the cycle of works, the purpose of which was development of:

- methods, rigging and equipment for non-destructive testing of tubes of SG,
- methods, rigging and materials for repair of imperfect tubes of SG,
- methods, rigging and materials for protecting of internal surface of tubes of SG from corrosive-erosive damages.

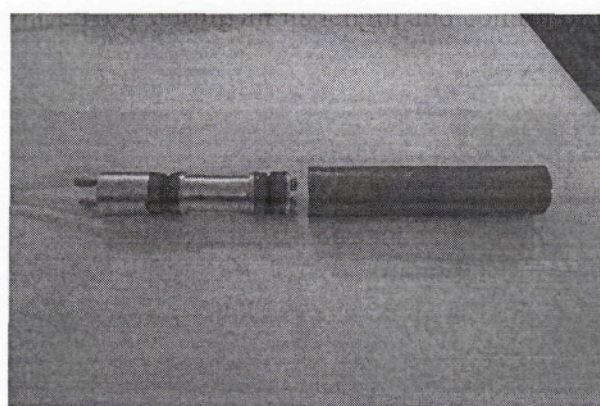
The ultimate goal of our work was creation of technology of inspection and repair HET, allowing to prolong the resource of exploitation of heat-exchange apparatuses of NPP. And the basic condition of realization of this purpose was monitoring of the state HET during the process of repair. Therefore as one of basic methods of non-destructive control a visual-optical method was chosen. We are construct videoendoskop, allowing to conduct the continuous inspection of the state of internal surface HET during all its length and control of repair technology (fig.3,4).



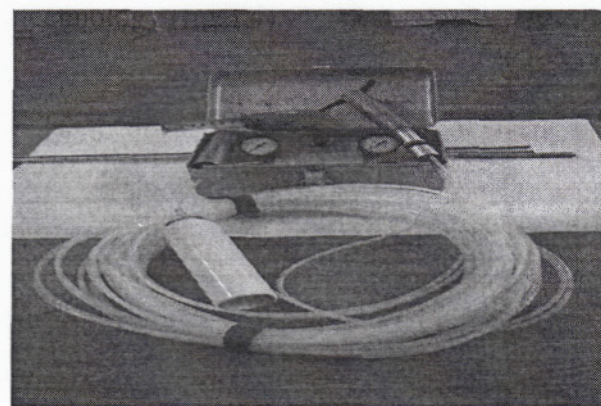
(fig.3)



(fig.4)

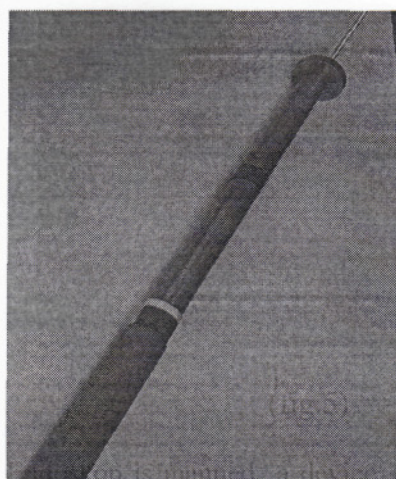


(fig.5)



(fig.6)

Endoskop is manned a device – “pipe leaktester” (fig.5,6) developed for testing of areas of surface HET, in which after visual examination the presence of through defects was assumed. A synonymous answer gives a test by vacuum-manometry and chemical methods for a question about the presence of through defects.



(fig.7)

In accordance with the technology discovered in HET walls flows repair with the use of the cangovoy rigging (fig.7) under a continuous visual supervision.

The rigging allows:

- to pressurize through defects by glue-sealants, for example, anaerobic compositions by gluing on the area of defect inside the tube of hobs-compressions,
- to pressurize through defects by electroconductive spacklings, over which inflict electrochemical coverage, containing nanoparticles of diamond.

Rotined tests conducted in a laboratory of ISI firm (tabl.1) in accordance with the standard of ASTM showed, that:

- agdeziya of such coverage to copper basis corresponds maximally possible - 5 marks,
- hardness of coverage on a graphite scale – higher 10N,
- firmness to the abrasive wear corresponds a maximum -1 mark,
- an abrasive wear in a water environment is minimum.

RESULTS OF TESTS.

Table 1.

Index	Method	Values of indexes for the standards of coverages							
		1	2	3	4	5	6	7	8
Thickness of coverage, mkm	[1]	10,2	28,4	17,6	18,6	19,4	20,1	29,5	19,9
Agdeziya of coverage, mark	[2]	5	5	5	5	5	5	5	5
Hardness on a graphite scale	[3]	Higher 10H	Higher 10H	Higher 10H	Higher 10H	Higher 10H	Higher 10H	Higher 10H	Higher 10H
Elasticity at squeezing out, mm	[4]	9,4	6,9	8,2	2,3*	3,8*	7,9*	6,3*	8,9
Firmness to the abrasive wear, mark	[5]	1-2	1	1	1	1-2	1-2	1	1-2
An abrasive wear a water environment	[6]	2	1-2	1-2	1-2	2	2	1	2

The tests of corrosion showed stability of protective coverage in 5 % NaCl during 120 hours.

The most preferable to application is the coverage N 7, rotining the greatest ball at the tests of abrasive firmness in a liquid environment, here possessing mechanical durability higher than durability of alloy on which coverage was inflicted on.

Thereby causing of the developed electrochemical coverage on an internal surface HET at a thickness 20-30 mkm provides the assured defence of metal HET from erosion and corrosion, allowing to prolong the resource of work of heat-exchange apparatuses in 1,5-2 times.

Conclusions:

1. the technical decisions, developed authors in area of diagnostics of the state, repair and defence of heat-exchange tubes of condensers of NPP, got the positive estimation of the World association of organizations, exploiting the atomic stations. In the decision of seminar of VAO AES from 25.11.2009 (Odessa) perspective of application of the offered solutions is marked for repair and defence of heattransfer surfaces of condensers of turbines from corrosion and erosion.
2. the tests conducted in the conditions of Zaporozhskaja NPP showed perspective and assured quality of repair HET with the use of new technology.