IMPROVEMENT OF GAS MONITORING METHODS IN WATER OF THE HYDROGEN-WATER COOLING SYSTEM OF NPP'S TURBINE GENERATOR

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The relevance of research is to ensure and improve the reliability of turbine generators (TG) with a hydrogen-water cooling system by monitoring the content of dissolved gases in the water of a hydrogen-water cooling system with monoethanolamine (MEA) – C_2H_7NO and water vapor in the cooling hydrogen of the turbine. In this work, the influence of ultrasonic vibrations on the decomposition of a mixture of water and turbine oil, organic acids (acetic acid - $C_2H_4O_2$, formic acid - CH_2O_2, oxalic acid - $C_2H_2O_4$) or monoethanolamine was determined. The distribution coefficients values were definedd for the following dissolved gases H_2, O_2, N_2, CO, CH_4, C_2H_2, C_2H_4, C_2H_6, C_3H_6, C_3H_8, which are of degradation products of water mix components when exposed to ultrasonic oscillation in the following system: «dissolved gas – mixture «water + monoethanolamine» – extractant argon (Ar)». The obtained values of the Ki distribution coefficients for dissolved gases in systems «dissolved gas – mixture «water + C_2H_7NO» – extractant argon (Ar)» at a temperature of 293 K and a concentration of C_2H_7NO at the level of 1 g/dm^3 are close to similar values for dissolved gases in deionized water. The principle flow chart of multichannel gas chromatograph for detecting dissolved gases in water and steam of water in hydrogen was developed. Developed flow chart of 4-chennel gas chromatographer for defining dissolved gases in water includes the one gas chromatographer with conductivity detector, methanator, flame ionization detector, argon gas-bearing and supplementary gases of hydrogen and air.

Key words: *cavitation, chromatography, gases, hydrogen, monoethanolamine, turbine generator, water.*

1. Introduction

To producing electricity, the TBB –type turbine generators are widely used at Ukrainian NPPs.

The following cooling media are used: water (H_2O) for stator coil, hydrogen (H_2) for rotor core and winding [1]. Application of H_2 requires arrangement of special oil sealing of turbine generator shaft.

Herewith, the steam of water from moistened oil ingresses in volume of turbine generator hydrogen that often results in electric-based deficiencies in rotor winding and leads to corrosion of internal elements of turbine generator. While being operated, a turbine generator is affected by vibration in wide frequency range that may lead to cavitation mode in the cooling water flow [1]. It may lead to high-rise short-term temperature and pressure increasing in cooling water [2]. Herewith, pressure can reach 1000 MPa and the temperature 5000 K [3]. Cooling water often contains monoethanolamine (C_2H_7NO), which characterizes the monoethanolamine water-

chemistry [4]. In case of oxygen (O_2) availability, C_2H_7NO may be subjected to thermal and oxidative degradation [5].

Reference [1] defines that the monitoring of H_2 supply in cooling H_2O in TBB-type TG may be performed by gas chromatographer method (GC method). Herewith, the technical and metrological requirements for the implementation of this GC method are not established. This reference also defines that the monitoring of steam content in water and gases, O_2, N_2 in cooling H_2 in turbine generator may be carried out by using the different measurement methods. It is also defined in reference [1] that the monitoring of hydrogen supply in cooling water of TBB-type turbine generator can be carried out by using gas chromatographer method. This method was developed in 1968 and is thought to be outdated – measurement duration may last 1.5 hours. This method requires improvement according to up-to-date measurement tools.

In reference [4], it is outlined, that the man-made organic impurities (oil products) might be available in cooling water. Herewith, the possible products of their degradation under the impact of vibration and cavitation mode in the cooling water in case of monoethanolamine availability are not determined.

It was shown in [5] that the thermal and oxidative destruction of C_2H_7NO in water accumulates the following aggressive organic acids, such as HCOOH, CH_3COOH, $HOCH_2COOH$, HOOCCOOH, $HOCHCH_3COOH$, H_2NCHCH_3COOH are build up in water. The possibility of a chemical reaction of these organic acids with metal structural elements of the turbine generator and pipelines under vibration and

cavitation conditions in cooling water is not shown in this work.

It was shown in [6] that, provided that MEA is present in water, acetic and oxalic acids are accumulated in it. The possibility of chemical reaction of these organic acids with metal elements of TG construction and pipelines is not demonstrated in this work.

The purpose of the study is to ensure the reliability of a turbine generator with a hydrogen-water cooling system with monoethanolamine (C_2H_7NO) by monitoring the content of gases such as H_2, O_2, N_2, CO, CH_4, C_2H_2, C_2H_4, C_2H_6, C_3H_6, C_3H_8 and of water steam that contains in the cooling hydrogen of the steam generator.

In order to achieve the purpose, the following tasks have been performed:

– defining the ultrasonic oscillation effect on degradation of water mixture with petroleum turbine oil, organic acids, (acetic acid formic acid and oxalic acid) or with monoethanolamine;

– defining the values of distribution coefficient for dissolved gases such as H_2, O_2, N_2, CO, CH_4, C_2H_2, C_2H_4, C_2H_6, C_3H_6, C_3H_8, in the system: «dissolved gas – mixture «water + monoethanolamine» – extractant argon (Ar)»;

– development of principal flow chart of multi-channel gas chromatograph for detecting dissolved gases and water steam.

2. Tools, materials and methods

The research has been performed by using: fresh mineral turbine oil of Tp-30 brand; deionized water; monoethanolamine aqueous solutions: Mixture №1 («water + $C_2H_4O_2$ + CH_2O_2 + $C_2H_2O_4$»); Mixture №2 («water + monoethanolamine»); Mixture №3 («water + monoethanolamine + mineral turbine oil of the Tp-30 brand»).

Concentration of each components of the mixtures (except turbine oil) – 1 g/dm³. The concentration of turbine oil is 5 mg/dm³. Volumes of mixtures – 15 cm³. Mixtures№ 1, № 2, № 3 before using were saturated with air at a temperature T = 293 K. In a separate experiment, the mixture № 2 was saturated with hydrogen at a temperature T = 293 K. While performing measurements the following equipment were used: gas chromatograph «Crystal 2000M» (Russia) with gas dispensers, methanator (for the conversion of CO and CO₂ into CH₄), thermal conductivity detector (TCD), and flame ionization detector (FID); gas chromatographer «LHM-80» (Russia) with gas dispensers and TCD detector.

Ultrasound generator «Rodnychok» (Ukraine) (irradiation frequency 35 up to 125 kHz, power 20 Watts) for acoustic irradiation of Mixtures № 1, № 2, № 3; device (extractor) for accelerating equilibrium (Russia) with a rotating drum for placing syringes in volumes of 20 cm³ or 50 cm³ with analyzed samples. Mixtures № 1, № 2, № 3 and gaseous extractants for establishing phase equilibrium in systems «Mixture – extraction solvent»; extractant argon (Ar); graduated gaseous mixtures of H₂, CH₄, C₂H₆, C₂H₄, C₂H₂, CO, CO₂, O₂, N₂, C₃H₆, C₃H₈, in argon; saturated distilled water. Argon is chosen as an extractant taking into account its gas-bearing properties in gas chromatograph. Measurements have been performed at a temperature of (293±0.5) K. Duration: gas extraction of components from mixtures № 1, № 2, № 3 – 10 minutes; Ultrasound effect on the Mixture № 1, № 2, № 3 – to 2 hours at temperature of T = 293 K. The gas chromatograph registration of components has been performed by using: TCD – for H₂, O₂, N₂, water steam; FID – for CH₄, C₂H₆,

C₂H₄, C₂H₂, CO, CO₂, C₃H₆, C₃H₈. Figure 1 demonstrates developed installation for performing measurements.
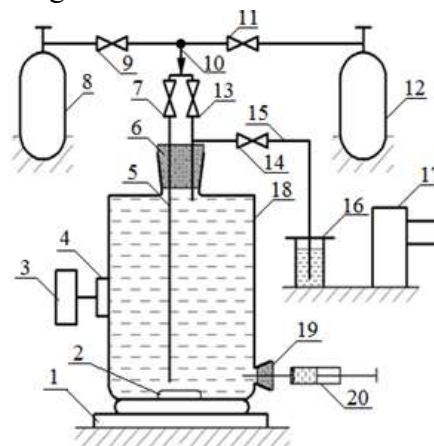

Fig. 1. *Installation for measurements:* *1 – magnet; 2 – magnetic stirrer; 3 – ultrasound generator; 4 – ultrasonic emitter; 5, 10, 15, 21, 22 – pipelines; 6 – cover; 7, 9, 11, 13, 14 – cranes; 8 – air cylinder; 12 – cylinder with hydrogen; 16 – hydraulic gate valve; 17 – extractor; 18 – vessel with the mixture; 19 – mixture selection assemble; 20 – syringe*

To determining the dissolved gases content in Mixtures № 1, № 2, № 3, the following was used: static way of GC measurement method by using gaseous extracting solvent and corresponding variants of equilibrium gas phase analysis methods in systems «Mixture – dissolved gas – gaseous extract»; method of absolute calibration in determining of dissolved gases content in gaseous extracts by using gaseous graduated mixtures. In the GC determination of the dissolved gas C_0 concentration in water, the calculation formulas used for two consecutive gas isothermal extractions were used:

$$C_0 = \frac{S_{\kappa}}{K_{z}} \cdot \left(K_p + \frac{V_e}{V_{eo}} \right), \qquad (1)$$

where S_{κ} – is GC peak area for the analyzed dissolved gas after its first gas extraction;

K_e – graduated factor for FI detector or TCD of gas chromatograph for the analyzed dissolved gas; V_{eo} – sample volume of analyzed water; V_e – is the volume of gaseous extractant; K_p – is the distribution coefficient for the analyzed dissolved gas in the system «Mixture – dissolved gas – gaseous extract».

The K_p distribution coefficient is determined by the following formula:

$$K_p = \frac{S_1}{S_2 - S_1} \cdot \frac{V_e}{V_{eo}}, \qquad (2)$$

where S_1, S_2 – are the areas of GC peaks for the analyzed dissolved gas after the first and second successive gas extraction from the Mixture № 1, № 2, № 3.

Each value of the dissolved gas concentration was obtained as a result of five (n = 5) parallel measurements with a confidence level of $p = 0.95$.

The coefficient of normalized deviations depending on the number of degree of variance $f = n - 1$, for n = 5 matters $t = 2.78$. In determining the H_2O content in gaseous H_2, the method of absolute calibration with using the mixtures of water steam in gaseous argon was used.

3. Results and discussions

3.1 Determination of ultrasonic vibrations effect on the degradation of a mixture of water and organic acids, monoethanolamine, turbine oil.

Table 1 provides the results of determining the ultrasonic vibrations effect on the degradation of Mixtures № 1, № 2, № 3, which are saturated with air.

Table 1. *The results of determining the ultrasonic vibrations effect on the degradation of deionized water mixtures with organic acids, monoethanolamine, and turbine oil*

Mixture	Dissolved gas concentration, C_i, % by volume						
	H_2	CO	CO_2	CH_4	C_2H_2	C_2H_4	C_2H_6
№1	0.001	0.015	0.055	0.03	–	–	–
№2	0.001	0.025	0.07	0.04	–	–	–
№3	0.060	0.06	0.14	0.05	0.12	0.16	0.10

In the Table 1: C_i – concentration of dissolved i-th gas in the mixture, volumetric part, after irradiation of Mixtures № 1, № 2, № 3

The Table 1 shows that the degradation of Mixture №1 or Mixture № 2, saturated with air, under the ultrasonic vibrations leads to the accumulation of dissolved gases such as CH_4, CO, CO_2 in the mixture.

According to the Table 1 it follows that the degradation of Mixture № 3 containing mineral turbine oil Tp-30 brand, leads to the accumulation dissolved gases H_2, CO, CO_2, CH_4, C_2H_2, C_2H_4, C_2H_6 in the mixture. This allows us to conclude that the compound of cooling water used in the equipment of the power plant might be controlled by the content of petroleum product in it after the oil cooling «cooled oil - cooling water» type

turbine generator. For that the sample of this water should be subject to ultrasound treatment. The Table 2 provides the results of determining the ultrasonic vibrations effect on

the degradation of the Mixture № 2, which is pre-saturated with hydrogen.

Table 2. *The results of determining the ultrasonic vibrations effect on the degradation of deionized water mixtures with monoethanolamine*

Mixture	Dissolved gas concentration, C_i, % by volume						
	H_2	CO	CO_2	CH_4	C_2H_2	C_2H_4	C_2H_6
№2 before irradiation	1.82	0.0001	0.002	–	–	–	–
№2 after irradiation	1.7	0.001	0.004	0.04	–	–	–

According to the Table 2: C_i is a concentration of dissolved i-th gas in the mixture.

Table 2 shows the following results: before irradiation of the Mixture №2 saturated with hydrogen, the concentrations of CO and CO_2 have values from 0.0001 to 0.002 % by volume; after irradiation of a Mixture № 2 saturated with hydrogen, its degradation under the acoustic oscillations leads to the accumulation CH_4, CO, CO_2 in the mixture and a decrease of hydrogen concentration. Increasing of CO_2 in distilled (deionized) water raise its conductivity, that has undesirable effect for cooled electrical coil of turbine generator. It requires purification of makeup water to be brought (to be filled) in

cooling system of TBB-type generator stator coil from monoethanolamine.

3.2 The results of determining the values of the distribution coefficients for dissolved gases in the «dissolved gas – mixture «water + monoethanolamine» – extractant argon (Ar)».

Table 3 shows the results of determining the values of the distribution coefficients of K_i for dissolved gases H_2, O_2, N_2, CO, CH_4, C_2H_2, C_2H_4, C_2H_6, C_3H_6, C_3H_8 in water in the systems «dissolved gas – mixture «water + C_2H_7NO» – extractant argon (Ar)» at temperature of 293 K and a concentration of C_2H_7NO at the level of 1 g/dm^3.

Table 3. *The results of determining the values of the K_i distribution coefficients for dissolved gases in the systems «dissolved gas – mixture «water + monoethanolamine» – extractant argon (Ar)»*

Gas	H_2	O_2	N_2	CO	CH_4	C_2H_2	C_2H_4	C_2H_6	C_3H_6	C_3H_8
K_i	0.019	0.033	0.017	0.0244	0.037	1.10	0.13	0.050	0.22	0.038

The Table 3 shows that the obtained values of the K_i distribution coefficients for dissolved gases H_2, O_2, N_2, CO, CH_4, C_2H_2,

C_2H_4, C_2H_6, C_3H_6, C_3H_8, in systems «dissolved gas – mixture «water + C_2H_7NO» – extractant argon (Ar)» at a temperature of

293 K and a concentration of C_2H_7NO at the level of 1 g/dm³ are close to similar values for dissolved gases in deionized water [1]. This allows using of GC methods to determine these gases in a mixture of «water + C_2H_7NO». Thus, the increasing of the dissolved gases content in the flow of the mixture «water + C_2H_7NO» after the pump, which ensures the circulation of this mixture in the hydrogen-water cooling system with MEA, may indicate the depressurization of this pump or its pipes.

3.3 The multichannel gas chromatograph structural flow chart for determination of dissolved gases in water and steam of water in gaseous hydrogen.

Figure 2 shows a structural flow chart of a 4-channel gas chromatograph for the determination of dissolved H_2, CO, CO_2, CH_4, C_2H_2, C_2H_4, C_2H_6 in water and water steam in gaseous *hydrogen*. If petroleum products are available in the water, their presence can be determined by the presence of dissolved gases

C_3H_6, C_3H_8, C_4H_{10}, C_4H_8 in H_2O after treatment of water by ultrasonic oscillations according to the method described in reference [2].
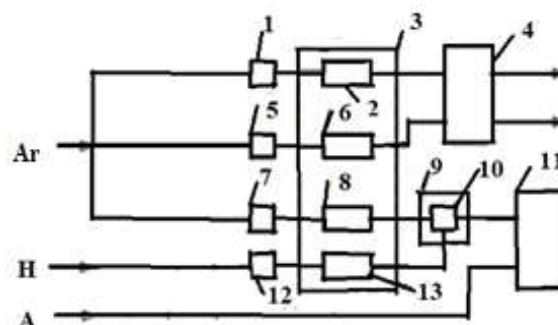

Fig. 2. *Principle structural flow chart of 4-channel gas chromatograph for the determination of dissolved gases in water and water steam in gaseous hydrogen: 1, 5, 7, 12 – gas dispenser taps with dosing loops; 2, 6, 8, 13 – chromatographic columns; 3, 9 – heating block; 10 – methanator; 4 – thermal conductivity detector (TCD); 11 – flame ionization detector (FID); Ar, H, A – argon, hydrogen, air.*

Table 4. *The main characteristics of the 4-channel gas chromatograph measurements elements*

Characteristics of chromatograph measuring channels elements
Measuring channel № 1 to determine the water steam content in hydrogen. Elements: chromatographic column pos. 2 – sorbent «Polysorb-1»; gas tap-dispenser pos. 1; $t_{xк}$= 393 K, $t_{дтп}$= 423 K; working chamber TCD pos. 4
Measuring channel № 2 to determine the H_2, O_2, N_2 dissolved gases content in water. Elements: chromatographic column pos. 6 – sorbent «NaX»; gas tap-dispenser pos. 5; $t_{xк}$= 333 K, $t_{дтп}$ = 373–423 K, comparative chamber TCD pos. 4.
Measuring channel № 3 to determine the CO, CH_4, CO_2, C_2H_4, C_2H_6, C_2H_2 dissolved gases content in water. Elements: column chromatograph pos. 8 – sorbent «Porapak N 80/100»; gas tap-dispenser pos. 7; $t_{xк}$= 313 K, $t_{м}$= 598 K, $t_{пид}$= 473 K, $υ$ = 12 K/min. $t_{xк}$=313 K to $t_{xк,кон}$= 453 K, FID pos. 11, Ar gas – carrier line.
Measuring channel № 4 to determine the content of CH_4, C_3H_6, C_3H_8, C_4H_{10}, C_4H_8 dissolved gases in water. Elements: chromatographic column pos. 13 – sorbent «Al_2O_3»; gas tap-dispenser pos. 12; $t_{xк}$= 313 K, $t_{м}$= 598 K, $t_{пид}$= 473 K, $υ$ = 12 K/min from $t_{xк}$= 313 K to $t_{xк,кон}$= 453 K, FID pos. 11, H_2 line

According to the table 4 table: $t_{хк}$, $t_{дтп}$, $t_{пид}$, $t_м$, $t_{хк,кон}$, $t_{исп}$ – temperatures of chromatographic columns ($t_{хк}$ – initial, $t_{хк,кон}$ – final), TCD, FID, methanator, K; v – is the heating rate of GC columns, K /min.

During the development of the structural flow chart of 4-channel gas chromatograph for the determination of dissolved gases in water and water steam in gaseous hydrogen, was defined the following:

1. The developed structural flow chart includes: gas taps-dispensers with calibrated dosing loops; GC columns; thermostats; detectors – TCD and FID; gas supply lines Ar, H_2, air. This technical solution allows measuring the content of gases H_2, N_2, O_2, CO, CH_4, CO_2, C_2H_4, C_2H_6, C_2H_2, C_3H_6, C_3H_8, C_4H_8, C_4H_{10} y H_2O in water and water steam taken from one sample of water or gaseous hydrogen by the using of one 4-x channel gas chromatograph.

2. The calculated value of the limits for determining the humidity of gaseous hydrogen has a value of 0.16 g/m^3. Relative error of the measurement result is no more 40% with a confidence level p = 0.95. The estimated value of the detection limits of

water steam is $1.6 \cdot 10^{-7}$ g. Calibration samples of water steam in gaseous argon are introduced into the chromatograph using a gas tap-dispenser pos. 1.

3. To determining the content of CO, CH_4, CO_2, C_2H_4, C_2H_6, C_2H_2 y H_2O gases in water, the equilibrium gas sample (or calibration mixtures of gases) is introduced into the chromatograph using a gas tap-dispenser pos. 7.

4. To determining the content of CH_4, C_3H_6, C_3H_8, C_4H_{10}, C_4H_8 gases in water, equilibrium gas sample (or calibration mixtures of gases) is introduced into the chromatograph using a gas tap-dispenser pos. 12.

5. To determining the content of H_2, O_2, N_2 gases in H_2O, equilibrium gas sample (or calibration mixtures of gases) is inserted into the chromatograph using a gas tap-dispenser pos. 5.

Table 5 provides the limits of allowable relative error values of the detecting of measuring gases concentrations (δ_i, % Rel) and water steam, depending on the range of their concentrations of C_i.

Table 5. *The value of the allowable relative error δ_i and determining the concentrations of measuring gases and water steam depending on their concentrations range*

The range of measuring dissolved gases concentrations of C_i, % by volume,				δ_i, %
H_2, O_2, N_2 in water; water steam in hydrogen	CH_4, C_2H_4, C_2H_6, C_3H_6, C_3H_8, C_4H_8, C_4H_{10}	C_2H_2	CO, CO_2	
$< 5 \cdot 10^{-3}$	$< 10^{-3}$	$< 5 \cdot 10^{-4}$	$< 5 \cdot 10^{-3}$	< 50
$(5–25) \cdot 10^{-3}$	$(1–3) \cdot 10^{-3}$	$(5–15) \cdot 10^{-4}$	$(5–25) \cdot 10^{-3}$	< 50
$(25–50) \cdot 10^{-3}$	$(3–50) \cdot 10^{-3}$	$(1,5–25) \cdot 10^{-3}$	$(25–100) \cdot 10^{-3}$	≤ 20
$> 5 \cdot 10^{-2}$	$> 5 \cdot 10^{-2}$	$> 5 \cdot 10^{-2}$	$> 0,1$	≤ 10

The value of standard deviation of the output signal (RSD, % Rel) for TCD, FID gas

chromatograph (height, area, retention time for the measured dissolved gas) depending on

the range of concentrations of the measured

dissolved gas (C_i, %) given in Table 6.

Table 6. *The value of the standard deviation of RSD*

C_i, % by volume	< 0.002	0.002–0,01	0.01–0.1	0.1–1	1–10
RSD. % rel.	> 10	10	2	2	1

Table 7 shows the experimentally obtained values of the limits for the determination of C_{no} (volumetric %) the

concentrations of dissolved gases in water to performing measurements.

Table 7. *Limits of dissolved gases concentrations values in water*

№	Dissolved gas	C_{no}, % by volume	№	Dissolved gas	C_{no}, % by volume
1	H_2	$2 \cdot 10^{-4}$	4	CO, CO_2	$5 \cdot 10^{-4}$
2	CH_4, C_2H_6, C_2H_4	$1 \cdot 10^{-4}$	5	O_2, N_2	$1.5 \cdot 10^{-4}$
3	C_2H_2	$5 \cdot 10^{-5}$			

To determine the limits of measuring of the concentrations of water steam in gaseous hydrogen and calibration of the chromatograph, mixtures of water steam in gaseous argon at concentrations of water steam from 0.16 g/m³ to 17 g/m³ were used. To determine the limits of measuring the concentrations of gases H_2, CH_4, C_2H_6, C_2H_4, C_2H_2, CO, CO_2, O_2, N_2, C_3H_6, C_3H_8, C_4H_{10}, C_4H_8 in water and calibrate of chromatographic mixtures of these gases in gaseous argon at concentrations for each of the measured gases on the level of 0.5%.

4. Conclusion

1. The ultrasonic oscillations effect on the degradation of a water mixture and petroleum turbine oil, organic acids (acetic acid formic acid and oxalic acid) or with monoethanolamine was determined. Degradation products are the following gases H_2, CO, CO_2, CH_4, C_2H_2, C_2H_4, C_2H_6. It enables to develop the GC monitoring

methods to increase the operation reliability of TBB-type turbine generator.

2. The values of distribution coefficients for dissolved gases such as H_2, CO, CO_2, CH_4, C_2H_2, C_2H_4, C_2H_6, C_3H_6, C_3H_8, C_4H_{10}, C_4H_8 in the mixture «dissolved gas – mixture «water + C_2H_7NO» – extractant (Ar)» are determined. The obtained values of distribution coefficients for dissolved gases at T = 293 K and C_2H_7NO concentration of 1 g/dm³ are close to similar values for dissolved gases in deionized water. It enables to determine the content of these dissolved gases in water by GC methods.

3. The principle structural flow chart of a 4-channel gas chromatograph for determination of H_2, CO, CO_2, CH_4, C_2H_2, C_2H_4, C_2H_6, C_3H_6, C_3H_8, C_4H_8, C_4H_{10} and water steam in gaseous hydrogen has been developed. This made it possible to determine these components using a single gas chromatograph, which simplifies and reduces the cost of measurements.

5. These technical solutions enable to ensure and increase the operation reliability of the turbine generator with hydrogen cooling by the monitoring of dissolved gases in the water cooling of hydrogen-water cooling system using ethanolamine and the monitoring water steam in the cooling hydrogen of TG of TBB-type.

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УДОСКОНАЛЕННЯ МЕТОДІВ КОНТРОЛЮ ГАЗІВ У ВОДІ СИСТЕМИ ВОДНЕВО-ВОДНОГО ОХОЛОДЖЕННЯ ТУРБОГЕНЕРАТОРА ЕЛЕКТРОСТАНЦІЇ

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Актуальність дослідження полягає у забезпеченні та підвищені надійності експлуатації турбогенератора з системою воднево-водного охолодження. Метою дослідження є забезпечення надійності експлуатації турбогенератора з водневим охолодженням за рахунок контролю вмісту розчинених газів у воді системи воднево-водного охолодження із моноетаноламіновим (C_2H_7NO) водно-хімічним режимом та пару води в охолоджуючому водні турбогенератора. Завданнями дослідження є визначення впливу ультразвукових коливань на деградацію суміші води із турбінною оливою, органічними кислотами (оцтовою – $C_2H_4O_2$, мурашиною – CH_2O_2, щавлевою – $C_2H_2O_4$) або із моноетаноламіном; визначення значень коефіцієнтів розподілу для розчинених газів H_2, O_2, N_2, CO, CH_4, C_2H_2, C_2H_4, C_2H_6, C_3H_6, C_3H_8 у суміші «розчинений газ – суміш «вода +моноетаноламін» – екстрагент аргон (Ar)»; розробка принципової структурної схеми багатоканального газового хроматографу для визначення у воді розчинених газів та пару води у водні. При визначені впливу ультразвукових коливань на деградацію суміші води із нафтовою турбінною оливою, органічними кислотами або із моноетаноламіном, продуктами деградації є гази H_2, CO, CO_2, CH_4, C_2H_2, C_2H_4, C_2H_6. При визначенні коефіцієнтів розподілу K_i для розчинених газів у суміші «розчинений газ – суміш «вода +моноетаноламін» – екстрагент Ar» значення K_i при концентрації моноетаноламіну 1 г/дм^3 близькі для аналогічних значень у дистильованій воді. Розроблена принципова структурна схема 4-х канального газового хроматографу для визначення у воді розчинених газів та пару води у водні дозволяє визначати вміст розчинених газів у воді та пару води у водні із залученням одного газового хроматографу із детектором за теплопровідністю, метанатором, полум'яно-іонізаційним детектором, газом-носієм аргоном та допоміжними газами воднем і повітрям.

Ключові слова: *кавітація, хроматографія, гази, водень, моноетаноламін, турбінний генератор, вода.*