Тогда за год будет:

$$C_{год(св)} = 76500 * 12 = 918000 \text{ руб.}$$

Опираясь на данные, которые были получены ранее, можно подсчитать итоговую стоимость реализации системы освещения автодороги БГЭС:

$$C_{\sum} = З + C_{э} + C_{год(св)}, \quad (6)$$

$$C_{\sum} = 8084892 + 383160 + 918000 = 9386052 \text{ руб.}$$

5. Расчетная нагрузка на опору

Для подготовки бетонной площадки, на которой будут устанавливаться опоры освещения следует рассчитать массу всей системы освещения. Для этого введем следующие значения:

$$M_{\sum} = m_{св} + m_{о} + m_{кр}, \quad (7)$$

где $M_{\sum}$ – суммарная нагрузка опоры, кг; $m_{св}$ – масса светильника, кг; $m_{о}$ – масса основной опоры, кг; $m_{кр}$ – масса кронштейна, кг

$$M_{\sum} = 12{,}8 + 110{,}285 + 22{,}304 = 145{,}389 \text{ кг.}$$

Таким образом, для обеспечения безопасности водителей и пешеходов были разработаны основные технические решения, соответствующие заданным требованиям. В настоящее время работа по освещению автодороги находится на стадии разработки.

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Научный руководитель: к.т.н. А.В. Струмеляк, доцент КЭ ФЭиА БрГУ.

EFFECT OF REPLACEMENT OF CONDENSER TUBES ON CHARACTERISTICS OF NPP WITH VVER-800 REACTOR

Khalifa[1], K.V. Slyusarskiy[2]
Tomsk polytechnic university
ISHE, Butakov research center[2], 507I[1]

Right now, energy is one of the essential elements, which are needed for social and economic development [1]. In recent decades, populace development and financial advancement in numerous nations have quickened the development of fossil fuel utilization [2]. As a result, there was a genuine risk to the environment – worldwide warming [3]. Subsequently, in order to ensure the environment, it is fundamental to optimize the vitality structure to be able to guarantee the possibility of getting clean vitality and at the same time not have a negative effect on the financial development of nations, their advancement and well-being [4]. In comparison with conventional carbon vitality, atomic vitality is considered to be clean and relatively reasonable, conjointly plays an imperative part in lessening emissions of hazardous substances into the environment, which mitigates the impacts of global warming [5].At the same time, it should be noted that at traditional nuclear power plants, condensers are used to condensate steam to water. In the process of their operation, if a nuclear power plant is located in hot countries, it requires high heat transfer coefficient. The solution to this problem is the use of materials which have high heat transfer properties or decreasing of the thickness of the tube or some modification of its surface. Therefore the purpose of the work is to study the effect of replacement of condenser tubes on characteristics of NPP with VVER-800 reactor.

Condenser of NPP is basically shell-and-tube heat exchanger with steam flowing into intertubular space, while cooling water flows inside tube (figure 1). The condenser operation principle is based on creating vacuum due to phase transition of steam and corresponding sharp decrease in its volume. The heat rejection from condenser is realized using cooling water circulating through heat exchange tubes. The major factors, affecting this process are initial temperature of cooling water (which is determined majorly by climate and cooling water treatment system configuration), flow rate of cooling water and underheating. While the first two are determined by cooling water treatment system, the latter is determined purely by heat transfer surface area and intensity of heat transfer. The major ways of enhancing condenser performance without significantly increasing its cost, include promoting conductive heat transfer through heat exchange tubes and increasing convective heat transfer from both sides of cooling water and steam. Both these methods were considered in current study.

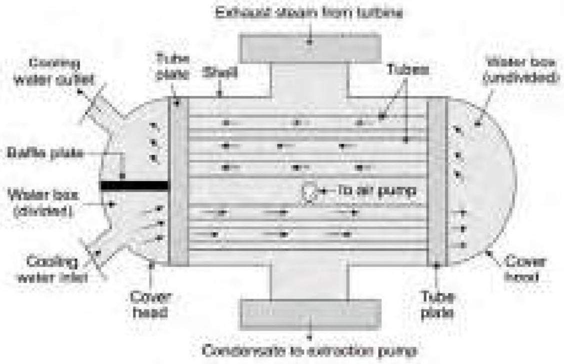

Fig. 1. Schematic diagram of Condenser

The initial data used for the calculation are presented in table 1.

The brief literature review revealed, that there are four major steel types, which could be used for tubes of condenser: stainless steel, titanium alloy, cupronickel and aluminum. The most effective method of improving convective heat transfer in conditions of condensing steam is to modify tube surface. However, modification methods for different materials are also different. Review of scientific literature revealed following methods and corresponding enhancing effects for all abovementioned tube types – table 2.

Table 1. Initial data for basic mode of NPP operation

Name	Symbol	Value
Exhaust steam flow per condenser	G_{c1}, kg/s	343,04
Condenser pressure	p_c, MPa	0,0055
Number of tube-side passes for cooling water	z	2
Coolant temperature at the inlet to the condenser	t_{w1}, °C	20
Coolant temperature at the outlet to the condenser	t_{w2}, °C	29,2
Speed of the cooling water in the tubes of the condenser	w_w, m/s	2,2
Inner diameter of condenser tube	d_{in}, mm	27

The required thickness of tubes of different material was calculated using following equation:

$$\delta = \frac{p \cdot d}{2 \cdot [\sigma] + d},$$

here p – pressure of cooling water in tubes (was chosen to be equal to 5 bar), MPa; d – diameter of tube (was chosen as standard value equal to 16 mm), mm; [σ] – creep strength of chosen tube material, MPa.

The overall heat transfer coefficient was calculated as:

$$\mathrm{k} = \left[\frac{1}{\alpha_1} + \frac{\delta}{\lambda} + \frac{1}{\alpha_2}\right]^{-1},$$

here α_1/α_2 – convective heat transfer coefficient from cooling water to tube/from tube to steam, W/(m^2 °C); λ – conductivity of tube material, W/(m °C).

Table 2. Surface modification methods and enhancing effect for all tube materials

	Stainless steal	Titanium alloy	Cupronickel alloy	Aluminum
Coating method	Sandblasting	Initiated chemical vapor deposition (ICVD)	Self-assembled monolayers (SAM)	Etching
Heat transfer coefficient enhancement	HTC enhanced by 44 % [6]	HTC increased 4-8 times [6]	HTC increased 14 times for copper-nickel tubes [6]	HTC enhanced by 25 % [6]
Coating method	Sandblasting			
Heat transfer enhancement	HTC enhanced by 102 % [6]			
Coating method	Etching			
Heat transfer enhancement	HTC enhanced by 15 % [6]			

The subcooling of steam then was calculated as:

$$\delta\mathrm{t} = \frac{\Delta t_w}{\exp\left(\frac{3{,}6\mathrm{k}}{\mathrm{c_p m d_c}}\right) - 1},$$

here $\mathrm{c_p}$ – heat capacity of water, kJ/(kg °C); m – cooling ratio (was assumed to be 55); $\mathrm{d_c}$ – condenser specific heat load, kg/(m^2 s).

Thus the saturation temperature in condenser at all studied modes was determined as:

$$\mathrm{t'_{sc}} = \mathrm{t_{w2}} + \delta\mathrm{t},$$

here $\mathrm{t_{w2}}$ – temperature of cooling water on the outlet of condenser, °C.

Then the saturation pressure p was determined for this temperature using steam tables.

Additional power of the turbine due to decreasing pressure was calculated as:

$$\Delta\mathrm{N_{add}} = \mathrm{G_{c1}} \cdot \left(\mathrm{h''_c} - \mathrm{h''_{c'}}\right)$$

here $h''_c/h''_{c'}$ – enthalpy of steam on the outlet of turbine in basic/new mode of condenser, kJ/kg.

Obtained calculation results for different tube materials and modification methods are presented in table 3.

Table 3. Results of enhancing heat transfer coefficient on pressure and additional electric power of NPP

Stainless steal		Titanium alloy		Cupronickel alloy		Aluminium	
p, kPa	N_{add}, kW	p, kPa	N_{add}, kW	p, kPa	N_{add},kW	p, kPa	N_{add},kW
5,23	549,22	4,70	1284,76	4,61	1590,67	4,98	346,82
5,07	896,69	4,62	1485,39				
5,38	235,75						

It could be seen, that the lowest pressure of steam – 4,61 kPa – in condenser obtained for cupronickel alloy modified by self-assembled monolayer. Still, application of copper at NPP is undesirable due to scaling formation, so the next best option – titanium alloy modified by initiated chemical vapor deposition could be recommended. While the cost of this solution is unclear, additional 1,6 MW of power will generate approximately at least 12,8 million rubles annually, which will likely cover all corresponding costs.

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Scientific supervisor: Candidate of Physical and Mathematical Sciences K.V. Slyusarskiy, Associate Professor REC I.N.Butakova of the ISHE TPU.

ОСОБЕННОСТИ УДАЛЕНИЯ ЖИДКОСТИ ИЗ СКВАЖИН ПХГ В ВОДОНОСНЫХ ПЛАСТАХ

А.Г. Гелдимурадов, С.Д. Агалыев
Международный университет нефти и газа

Как известно, наиболее обоснованным техническим решением [2] для нивелирования сезонной неравномерности потребления природного газа, является строительство и эксплуатация подземных хранилищ (ПХГ).

Для оценки неравномерности газопотребления в Туркменистане и необходимых резервных объёмов, были проанализированы показатели добычи и потребления газа в течение пяти лет. Коэффициент неравномерности общего потребления природного газа по Туркменистану, с учетом экспорта, меняется в пределах 0,82–1,3. Самая большая разница коэффициента неравномерности по месяцам приходится на систему жилищно-коммунального хозяйства, т. к. объем газа, используемый для отопления домов и других сооружений, в соответствии с сезоном меняется в широких пределах. Периодами коэффициент неравномерности потребления газа в жилищно-коммунальном хозяйстве, в отличие от других систем газопотребления, меняется в пределах 0,4–1,9.

Практически во всех странах, богатых природным газом, имеются ПХГ. Они строятся в выработанных нефтяных и газовых месторождениях, искусственно созданных соляных пещерах, природных полостях и пещерах, в водоносных пластах и в пустотах, образованных тепловыми методами в условиях вечной мерзлоты.

Цель нашей работы – обосновать преимущества строительства ПХГ в Туркменистане в водоносных структурах и сформулировать некоторые особенности эксплуатации скважин ПХГ.

Авторами [1] исследовался вопрос создания ПХГ в соляных полостях Туркменистана. Однако здесь, в первую очередь, встаёт необходимость решения экологических проблем, связанных с использованием соли, которая будет добываться для создания соляной полости.

Особенностью газовых месторождений Туркменистана является залегание на глубине около 3000 м [3]. По опыту создания ПХГ в выработанных пластах, глубина их залегания