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JUSTIFICATION FOR THE CHOICE OF MATERIAL FOR CONDENSER TUBES FOR STEAM TURBINE PLANTS OF NUCLEAR POWER PLANTS

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Introduction

A condenser is a type of heat exchanger that transfers heat from hot to cold fluid. The condenser condenses or cools the exhaust steam from the last stage of the steam turbine, either directly or indirectly with cooling water via a heat transfer medium.

Each low-pressure turbine typically has one condenser. The condenser is characterized by a large number of small tubes made of admiralty metal, copper, stainless steel, or titanium.

The condenser is essentially a large heat exchanger with horizontally mounted tubes. The tubes can be held up (or staked). In a water box, water from the circulating water system enters the condenser. The water level in the water box must be kept above the uppermost tubes or the condenser will not work properly. In general, the plant is more efficient when the circulating water is cold. When the condenser tubes become fouled, for example, by mud, plugging, or the accumulation of other materials that reduce the ability of the condenser tubes to transfer heat from the steam to the water, power plants become less efficient.

The water boxes are kept full by using an air ejector or other system that keeps the water level in the column above the tubes. Water collects at the bottom of the condenser's steam side in a hot well, which serves as the water source for the condensate pumps' suction.

The pressure within a steam condenser is kept below atmospheric pressure to improve efficiency. It is commonly used to reduce the backpressure of turbine exhaust.

1. Description of the condenser

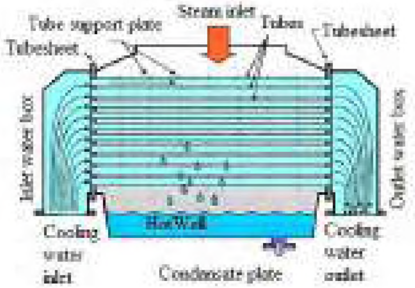

Fig. 1. Condensing unit schematic diagram

The cooling water inside a steam condenser is constantly flowing back and forth between the condenser and the cooling tower.

As a result, the heat from the condensed steam is transferred through the circulating cooling water when exhaust low-pressure steam from the turbine passes through the condenser and is converted to water.

2. Initial data for the calculation of the condenser

Table 1. Initial data

Parameter	Denomination, units	Value
Exhaust steam flow per condenser	$G_{c1}, kg/s$	514
Pressure in the condenser	p_c, MPa	0,005
Number of cooling water tube-side passes	z	1
The temperature of the coolant at the condenser's inlet	t_{w1}, °C	11
The speed of the cooling water in the condenser's tubes	$w_w, m/s$	1,9
Condenser tube sizes	$d_{out} x \delta_{wall}, mm$	25 × 1

3. Features of the thermal calculation of the

3.1. Tube materials used

The choice of material for the condensate heat exchanger tubes is a determining factor in its reliable operation. Brass, cupronickel, titanium and stainless steel are the most common condenser tube materials.

3.2. The overall heat transfer coefficient

A. Shcheglyaev's formula was used to calculate the overall heat transfer coefficient [1]. The type of tube material is set by a special coefficient a_m.

$$k = 4070 \cdot a \cdot \left(\frac{1{,}1 \cdot w_w}{d_{in}^{0{,}25}}\right)^x \cdot \left[1 - \frac{0{,}52 - 0{,}002 \cdot d_c \cdot \sqrt{a}}{1000} \cdot (35 - t_{w1})^2\right] \cdot \left[1 - \frac{z-2}{10} \cdot \left(1 - \frac{t_{w1}}{35}\right)\right],$$

where: k – in W/(m²·°C); $x = 0{,}12 \cdot a \cdot (1 + 0{,}15 \cdot t_{w1})$; $a = a_0 \cdot a_m$ is a coefficient that takes into account tube pollution and tube material; $a_0 = 0{,}65 \ldots 0{,}85$ is a coefficient that considers tube contamination; a_m is a correction factor that takes the tube material into account; $w_w = 1{,}9 \ldots 2$ m/s is the speed of water in tubes; t_{w1} is the temperature of the cooling water entering the condenser. This temperature is taken equal to 11 °C; $z = 1$ is the number of tube-side passes for cooling water.

3.3. Program for calculation

To calculate the capacitor and its performance indicators, an original program (in Excel) was developed in accordance with the algorithm [1]

4. Analysis of results

The calculation results are shown in figure 2 and table 2.

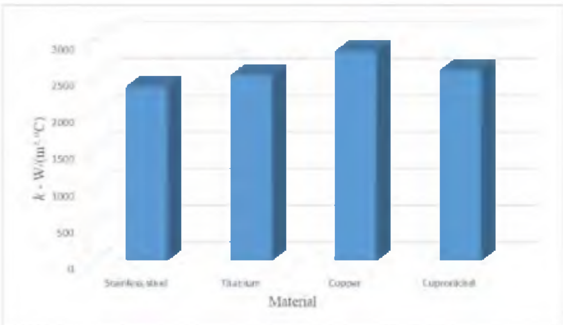

Fig. 2. The effect of the overall heat transfer coefficient in the material

The data in graph 1 show that the condenser with copper tubes has the highest heat transfer coefficient. This is because copper has s the best thermal conductivity. On other hand, the condenser with stainless steel tubes has the lowest heat transfer coefficient. The thermal conductivity of stainless steel does not exceed 20 W/ (m S).

The data in table 1 show that condensers with copper and titanium tubes have the best efficiency criterions values.

Table 2. Result for comparing between different material used in the condenser

Tube material	E, kW · h	$m_{уб}$, kg/kW	$\beta_{уб}$, m^2/m^3
Stainless steel	553,2	0,175	126,08
Titanium	584,7	0,091	126,2
Copper	684,7	0,147	126,04
Cupronickel	597	0,183	126,12

Notes: the value E can be considered energy efficiency or energy efficiency; $m_{уб}$ specific material consumption kg/kW; $\beta_{уб}$ compactness, m²/m³.

Taking into account the fact that copper alloys are not currently used in nuclear power plant condensers, it can be said that titanium is the best material for nuclear power plant tubes.

Conclusion

A program for design calculation was developed steam turbine condenser. Variant calculations of a condenser with different tube materials were carried out.

Criteria for comparing options were selected and calculated.

An analysis of the results of the criteria was carried out and the most effective material for condenser tubes was proposed.

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CHOOSE THE MATERIALS FOR STEAM TURBINES NPP

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Introduction

The majority of nuclear power reactors use a single-shaft turbine generator with a primary generator, three parallel multi-stage LP turbines, and one multi-stage HP turbine. The HP Turbine in my diplo-ma is a double-flow reaction turbine with around five stages and shrouded blades that generates between 30 and 40 percent of the gross power output of the power plant unit. LP turbines are about five-stage double-flow reaction turbines. About 60–70 % of the overall power output of the power plant unit is produced by LP turbines. Two bearings, one on each side of the turbine module, support each rotor of the turbine. Because of the necessity for high-temperature strength at a reasonable price, as well as the need to guarantee a good match of thermal properties, such as expansion and conductivity, the range of alloys used in steam turbines is very narrow. A steam turbine plant's condenser must deliver pressure behind the turbine with the beginning conditions listed below: incoming cooling water temperature, steam flow, and condenser pressure. You should be aware of the tubes' composition, size, and the quantity of cooling water passageways. [1].