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

Tube material	E, kW · h	$m_{уб}, kg/kW$	$\beta_{уб}$, m²/m³
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].

Material Problems of Turbines

• Creep

The permanent deformation that progresses over time under a continuous load or tension is called creep, often known as cold flow. It develops from prolonged exposure to significant external mechanical stress that is within the yielding limit and is more severe in materials that have been exposed to heat over an extended period of time. The qualities of the material, exposure period, exposure temperature, and the applied structural stress all affect how quickly a material deforms. If we employ materials at high temperatures, creep is crucial.

• Corrosion and erosion

Erosion Repeated electrochemical corrosion reactions and mechanical forces caused by relative motion between the corroding surface and the electrolyte are what lead to corrosion. The combination of erosion with another form of degradation, such corrosion, is called erosion-degradation, or erosion-degradation. Corrosion and wear combine to cause the material deterioration process known as erosion corrosion.

Systems that are susceptible to erosion corrosion include pipelines, valves, pumps, nozzles, heat exchangers, and turbines. Wear is a mechanical process that causes material deterioration on rubbing or impacting surfaces, whereas corrosion involves the substance going through chemical or electrochemical processes. Wear and corrosion both have the potential to accelerate one another.

• Steam Oxidation

Implementing ultra-supercritical steam power generation for increased efficiency and lower CO_2 emissions is closely related to steam oxidation behavior. Greater temperature increases efficiency, however when medium Cr-Ni, ferritic, or ferritic-martensitic steels are employed, higher corrosion rates happen in a steam environment.

The materials developed over 50–60 years ago are no longer suitable for ultra-supercritical regimes due to poor corrosion resistance and inadequate high-temperature creep and strength properties. These technologies require advanced austenitic steels and nickel (Ni)-based alloys with superior steam oxidation resistance [1].

How to choose material

To enable increases in steam turbine performance resulting from retrofit, materials technology is essential. For each significant component of the high temperature and low temperature cylinders, the choice of materials, the primary mechanisms of deterioration, material concerns, as well as any unique processes necessary, are highlighted. It is shown that the efficiency gains from retrofitting steam turbines may be obtained with little danger of component failure by choosing the right materials and using unique procedures [2].

Also from part of maximum thermal power we determine the number of flow through determine the maximum thermal power for steel and titanium and we can get number of flow and according to this we can choose the lowest number of flow [3].

Compare between material

The main distinction between the two materials is that titanium is an element while stainless steel is an alloy. Titanium's properties occur naturally in the metal. On the other hand, stainless steel is a metal alloy made up of chromium, iron, nickel, and other things.

Table 1. Of compare titanium alloy and stainless steel [4]

Parameter	Titanium alloy	Stainless steel
Density, kg/m^3	4700	7780
Young's modulus, GPa	250	215
Thermal conductivity, W/k·m	24,5	15
Hardness, HB	334	149
Cost, Rub/kg	400	1900

Calculation number of LPC

We will calculate the number of low-pressure cylinders with the same electrical power (900 MW) from calculation of maximum power for determine number of flow from equation (1) for each material:

$$n = \frac{N}{N_{max}}, \tag{1}$$

where, N – electrical power, MW; N_{max} – maximum electric power of a single-flow turbine, MW [3].

After calculate number of flow prefer choose the less number of flow (figure 1).

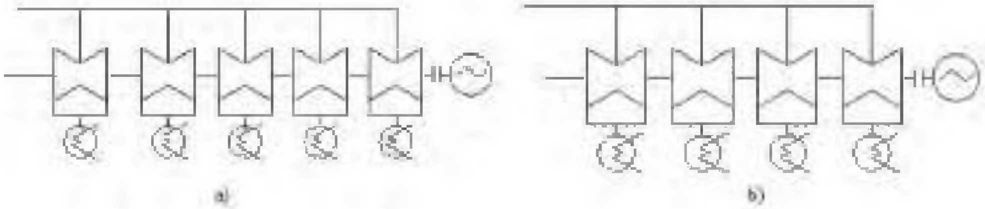

Fig. 1. Number of flow Low pressure turbine:
a) stainless steel b) titanium alloy

Calculation costs of material

The of material costs calculation according to the formula, million rubles (figure 2):

$$C_{cost} = \frac{M_{mat} \cdot c_{mat}}{10^6}, \tag{2}$$

where c_{mat} is price per 1 kg, rub/kg, for stainless steel c_{mat} = 350…400 rub/kg; for titanium c_{mat} = 1900…2100 rub/kg. M_{mat} is material weight, kg (figure 3).

Fig. 2. Compare between the material cost

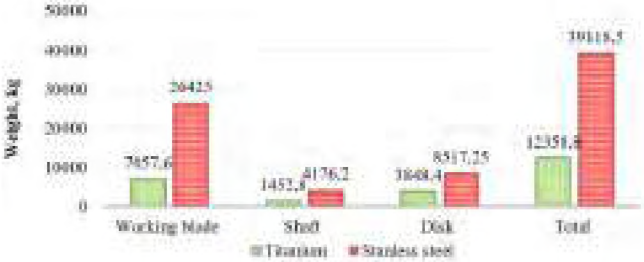

Fig. 3. Compare between the material weight

Conclusion

So after compare between two material titanium and stainless steel according to the calculation results prfering choose titanium because it has lower number of flow compare with steel also pure titanium is stronger than common steel. It is also twice as strong. The metal has the highest strength-to-density ratio of any metallic element and corrosion resistance, which are its two most valuable characteristics. At normal temperatures, titanium alloys have particularly high levels of corrosion resistance. The formation of a strong, protective oxide layer is the foundation of titanium's resistance to corrosion. Although titanium is "commercially pure," it possesses respectable mechanical qualities.

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PROJECT OF NPP POWER UNIT WITH AN ELECTRIC CAPACITY OF 1250 MW WITH DRY COOLERS

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Currently, energy is an important factor in the development of society [1]. In recent decades, population growth and economic development in many countries have accelerated the growth of fossil fuel consumption [2]. As a result, there was a serious threat to the environment – global warming [3]. Therefore, in order to protect the environment, it is necessary to optimize the energy structure in order to ensure the possibility of obtaining clean energy and at the same time not have a negative impact on the economic growth of countries, their development and well-being [4]. In comparison with traditional carbon energy, nuclear energy is considered to be clean and relatively inexpensive, and also plays an important role in reducing emissions of hazardous substances into the atmosphere, which mitigates the effects of global warming [5–6]. At the same time, it should be noted that at traditional nuclear power plants, cooling tower are used to cool water from the condenser. In the process of their operation, they are a source of water vapor emissions into the atmosphere. If a nuclear power plant is located near a city or forest, an additional source of humidity in the atmosphere can negatively affect people or animals. The solution to this problem is the use of a dry cooling tower at a nuclear power plant. Therefore, the purpose of the work is the project of a nuclear power plant with a dry cooling tower. A nuclear power plant with a VVER-type reactor was chosen as a prototype of the power unit. The prototype of the projected NPP is 1250 MW.

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

Table 1. Initial data

Name	**Symbol**	**Value**
Electrical power	N_e , MW	1250
Initial pressure	p_0, MPa	6.27
Initial temperature	t_0 , °C	t_{sat}
Final pressure	P_c , kPa	5
Number stages of Superheater	-	Double-stage
Feed water temperature	t_{fw}, °C	220
Deaerator pressure	p_d , MPa	0.58
Number high pressure heater	NHPH	-
Number mixing low pressure heater	NMLPH	-

The main elements of the projected NPP:
1) Nuclear power reactor;
2) Steam generator;
3) Thermal scheme of the NPP;
4) Condensation plant;
5) Dry cooling tower.

The schematic diagram of the projected nuclear power plant with a dry cooling tower is shown in figure 1.