equal to 0,985. However if we calculate the electrical efficiency via the formula (1), we will have two values: 0,363 and 0,370.

$$\eta_e = \eta_{oi} \cdot \eta_t \cdot \eta_m \cdot \eta_g \quad (1)$$

Next, it is necessary to calculate how many years should pass for the modernization to be completely paid off. Electrical power can be determined via formula (2).

$$N_e = N_o \cdot \eta_{oi} \cdot \eta_m \cdot \eta_g \quad (2)$$

The turbines K-500 are installed in the Leningrad NPP. Their rated power is equal to 500 MW. Electrical power before modernization was equal to 410 MW and after it is equal to 413 MW. 3 MW will bring an annual profit. Production and delivery of modules costs 100 million rubles. Consequently, if there is used only this power then the modernization will be repaid in 7 years.

In conclusion, it is necessary to add that the separator-steam reheaters modernization has increased the turbine efficiency and the NPP as a whole.

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THE ADDITIVE TECHNOLOGIES: INNOVATIONS IN NUCLEAR ENERGY

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The additive industry development has began with the 3D-printers. Now plants are plan to produce metal details via additive technology.

In RF this technology is at a low level. The main problem, that has appeared after the Russian ruble fall, is the foreign additive technologies high cost. For example, the titanium powders price for the Russian consumer is about 520 euros, but in Europe it is just 230 euros.

Rosatom has offered a program to solve this problem. Now this program is being realized. It consists of the subsections: technology, raw materials, equipment and standardization. There are involved 3 institutions for the development of metal powder production for 3D-printers. Over the past year, Russian scientists have developed several kinds of metal powders and a 3D-printer, for example in the TPU. Another collosal fact: the first Russian satellite, which was made in TPU on a 3D printer, was launched into orbit and it began to transmit signals.

According to the latest news, 22.03.2017 Rosatom presented model of new 3D-printer. This model works with 18.05.2017. Also, in the High-Tech Scientific Research Institute of Inorganic Materials named after Academician A.A. Bochvara (part of the Fuel Company of Rosatom "TVEL") established a working group to develop a pilot technology for 3D printing end parts of fuel assemblies. But, it is necessary to overtake foreign leaders. For example, the Siemens Company developed a component for the Krško NPP (Slovenia) – an impeller. Since 01.2017 it is used in pumps of NPP. Also, General Electric will create the world's largest 3D printer ATLAS by 2018. It is planned that the price of the Russian printer will be 40% lower than foreign printers, and the characteristics will be higher.

Additive technologies advantages:

1. new technologies allow us to reduce the components cost. It is easier to correct fault components in the design process via the additive technologies, but in the production stage of the traditional manufacture this will be more expensive;
2. the reduction of the components weight via the wall thickness decrease while preserving the desired properties;
3. the absence of any faults as for example with casting or molding;
4. create a complex and unique details.
5. The additive technology in the nuclear industry:
6. design of the reactor components;
7. replacement or repair of components during production. For example, steam turbine damaged rotor blades restoration.

In the nuclear industry there is a category of components with internal cavities and tubular structures complex system. For example, a surface heater, which is used to preheat feed water. Its main disadvantage is underheating. The main cause of this underheating is the air presence in a heater. With the 3D-printer help, we can create heater shell with the necessary properties: no air in the heater and increase its heating surface.

Let's come to the heater's scheme. We have calculated the influence of underheating on its efficiency. On the basis of the heat balance equation we have found that the under heating could be expressed via formula (1).

$$\theta_m = \theta \cdot e^{-\frac{kF}{Wc_p}} \qquad (1)$$

Underheating, temperature and pressure of the heating steam have been reduced, thus this improvement has increased heaters efficiency. [1]

Also, we plan to increase heating surface, which has a positive impact on the NPP efficiency. However capital charges for production of the new heater will increase on the heaters price - 125 million rubles (2), but operating costs will be decreased. The efficiency change is approximately equal to the electrical power (3).

$$\begin{cases} The\ cost\ of\ a\ new\ heater = 5000kg \cdot 5000\frac{ruble}{kg} = 25000000\ ruble \\ Total = 25000000 \cdot 5 = 125000000\ rubles \end{cases} \quad (2)$$

$$\eta \uparrow \rightarrow \delta\eta = \Delta N = 0{,}08; N_{new} = N + 0{,}08 \cdot N = 450 + 0{,}08 \cdot 450 = 486\ MW \quad (3)$$

The profit is expressed via formula (4).

$$P = (486 - 450)MW \cdot 10^3 \cdot 24 \cdot 365\frac{hour}{year} \cdot \frac{0{,}4\ kW}{hour} = 126144000\ \frac{ruble}{year} \quad (4)$$

Consequently, the new heaters will be repaid within 1 year (5).

$$\tau = \frac{125000000\ ruble}{126144000\frac{ruble}{year}} \cong 1\ year \quad (5)$$

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