ON THE POSSIBILITY OF REDUCING HARMFUL EMISSIONS IN HIGH-PARAMETER POWER UNITS

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Abstract

Steam-turbine units operating with above-critical parameters of water vapor have been studied. Researches show that when steam in power units moves from critical to high, supercritical and ultra-supercritical parameters, the initial parameters of the initial steam increase, the thermal efficiency of the steam energy cycle and the efficiency raise, the specific fuel consumption decreases, resulting in harmful emissions into the atmosphere (NOx, SOx and greenhouse gases CO2) are reduced, which reduces the environmental burden.

Keywords: steam turbine, temperature, pressure, ecology, fuel, harmful emissions, risk minimization, carbon dioxide.

I. Introduction

The socio-economic development of countries is directly related to the increase in electricity production. The development of traditional energy today is associated with the extraction and use of natural fuels, gas, oil and coal around the world. At present, natural fuel-operated power plants predominate, accounting for 68% of the world's electricity generation. However, the reduction of natural fuel sources, environmental pollution and other issues require the improvement of electricity generation and research in this area. Currently, steam power plants in the power system are considered more convenient to operate at a higher than critical steam (P_0 = 24 MPa, t_0 = 540⁰C), supercritical parameters (P_0 = 28-30 MPa, t_0 = 580-600⁰C) and ultra-supercritical (P_0 = 35-37 MPa, t_0 = 700 -720⁰C)

Passage to supercritical and ultra-supercritical parameters by increasing the initial parameters leads to an increase in efficiency, but such equipment uses heat-resistant, precious metals, which causes to a 30% increase in capital costs, however these costs are recouped in 3-4 years. At the same time, there are a number of thermodynamic features of increasing the parameters. Thus, due to the increase in pressure, the humidity in the final stages of the turbine may increase. Therefore, double intermediate heating is used. An increase in the temperature of the feed water in the ultra-supercritical units requires an increase in the number of regenerative heaters compared to the critical high-parameter unit, the use of one- and two-lift, electric and turbine pumps. Schematic diagram of the ultrasonic supercritical block is shown in Fig.1. shown. In this scheme, double intermediate heating was used.

During a single intermittent heating, the steam pressure leading to the intermediate heating is 15-20% of the initial pressure. In the case of double intermittent heating, the pressure of the steam supplied to the first intermediate heating is equal to 25-30% of the initial pressure, the pressure of the steam supplied to the second intermediate heating is equal to 6-9% of the initial pressure. The application of intermediate heating increases the efficiency of the cycle, while reducing the humidity in the final stages of the turbine. In the final stages, the humidity is 7.42%. In general, the coefficient of performance of such blocks is 50-51%. Reports show that the transition from critical to supercritical parameters reduces the specific fuel consumption by 7%. The supercritical unit saves 14.8 g / kWh of conventional fuel compared to the base standard unit. When passing from critical to ultra-supercritical parameters, the specific fuel consumption is reduced from 300 g / kWh to 251 g / kWh.

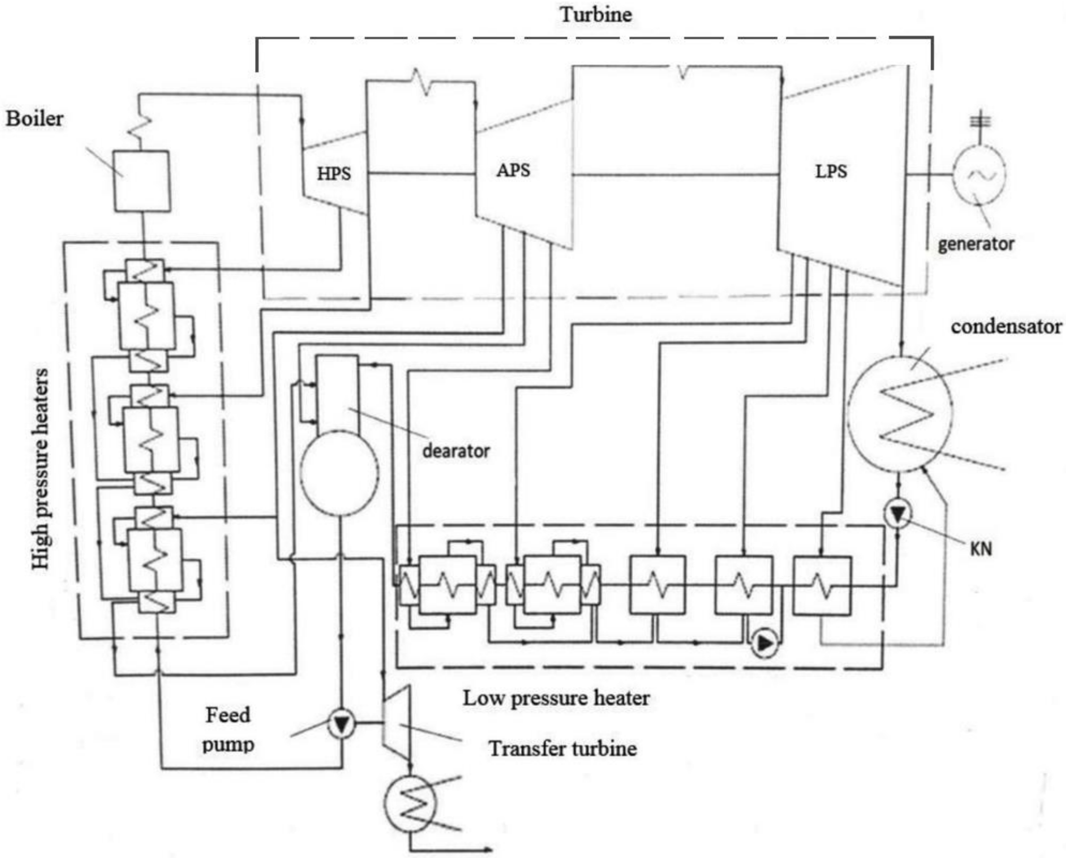


Fig. 1: *Schematic diagram of an ultra-supercritical power unit with double intermediate heating*

Fig. 2. shows the dependence of the power unit's net coefficient of performance on the initial temperature at different values of the vapor pressure in front of the turbine. An increase in the initial temperature of the steam raises the efficiency of the steam power unit. Fig. 2. shows that an increase in the initial temperature has a greater effect on the efficiency of the scheme than an increase in the initial pressure. For example, when the initial pressure is 30 MPa and the temperature rises from 600°C to 700°C, the relative increase in efficiency is 4.31%. Fig. 3. shows the dependence of the block on the initial parameters of the net coefficient of performance. The figure shows that when the pressure rises from 26 MPa to 35 MPa, the coefficient of performance increases 1.6%. Favorable temperature of the feed water also affects the technical and economic indicators. The temperature of the feed water is determined according to the water parameters in the high-pressure heaters before the boiler. Figure 4 shows the dependence of the net coefficient of performance. The on the feed water up to 30-35 MPa vapor Pressures in ultrasupercritical unit graphs show that at different steam pressures, the optimum temperature of the feed water is different. Thus, with the pressure increase, the temperature of the feed water increases. Between 30-35 MPa pressure, the optimum temperature of the feed water is 330-340°C.

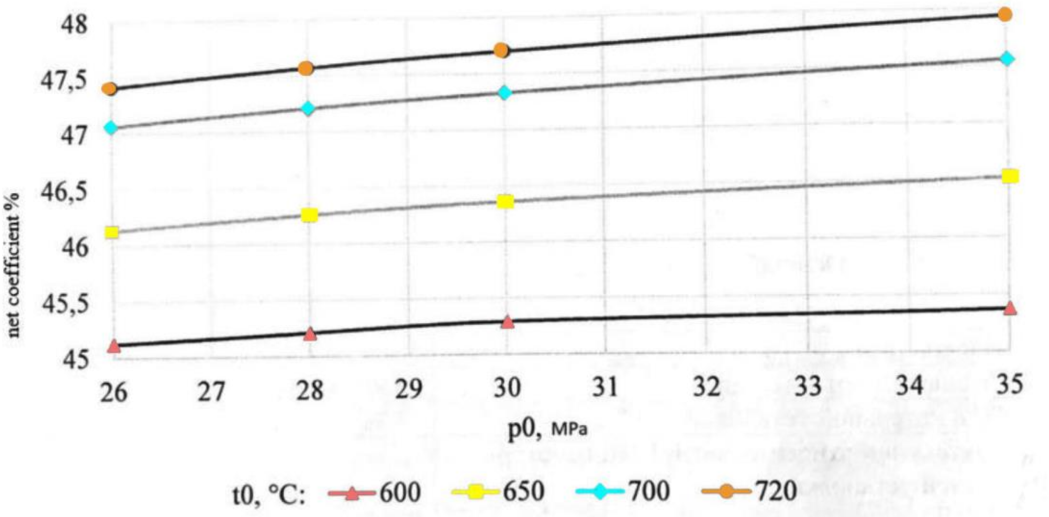


Fig. 2: *The dependence of the electrical net coefficient of performance of the power unit on the initial temperature at different pressures*

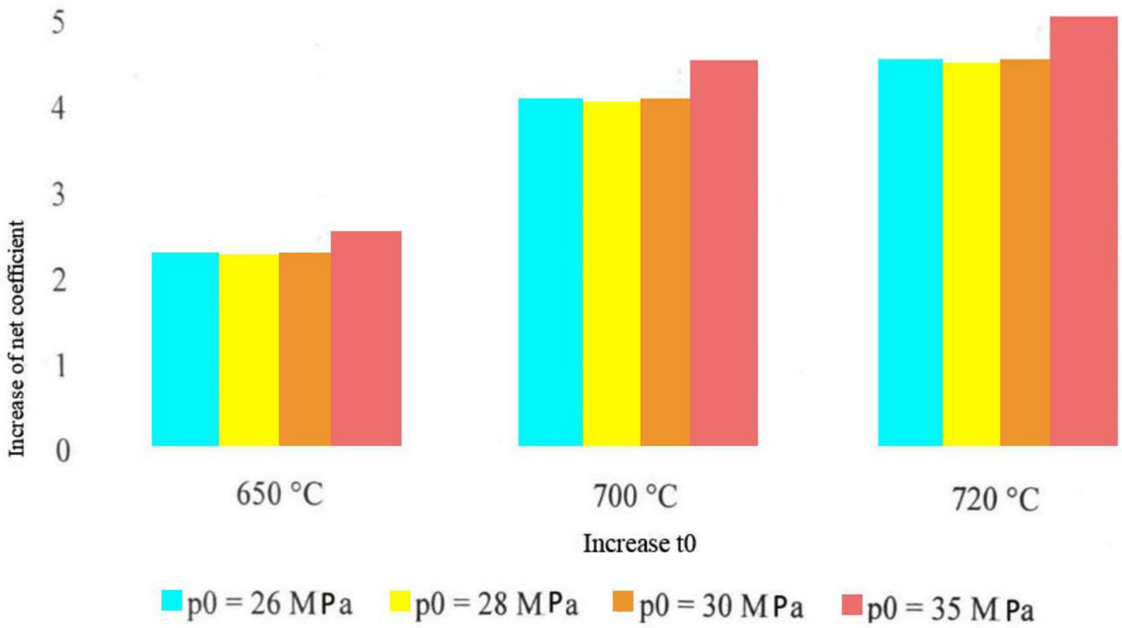


Fig. 3: *The increase in the coefficient of performance of the power block depends on the increase in the initial steam pressure*

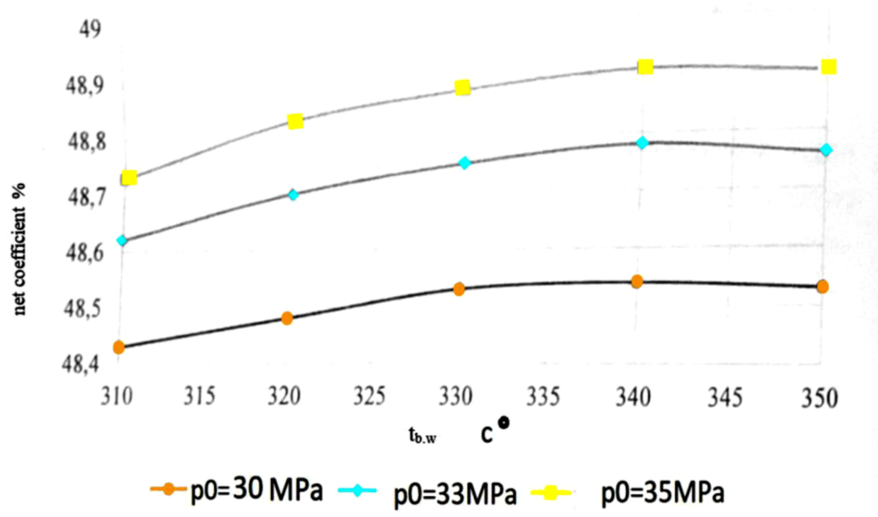


Fig. 4: *Dependence of net coefficient of performance on the temperature of the feed water*

Due to the increase in the initial parameters at these stations, as well as the use of double intermediate heating, the coefficient of performance (η_s) of the station increases, the specific fuel consumption decreases ($b_ş$) = $\frac{123}{\eta_s}$, the amount of flue gases released into the atmosphere and the amount of harmful substances also decreases. The amount of CO_2 released into the atmosphere is determined by the station's net coefficient of performance. The dependence is shown in Fig.5.

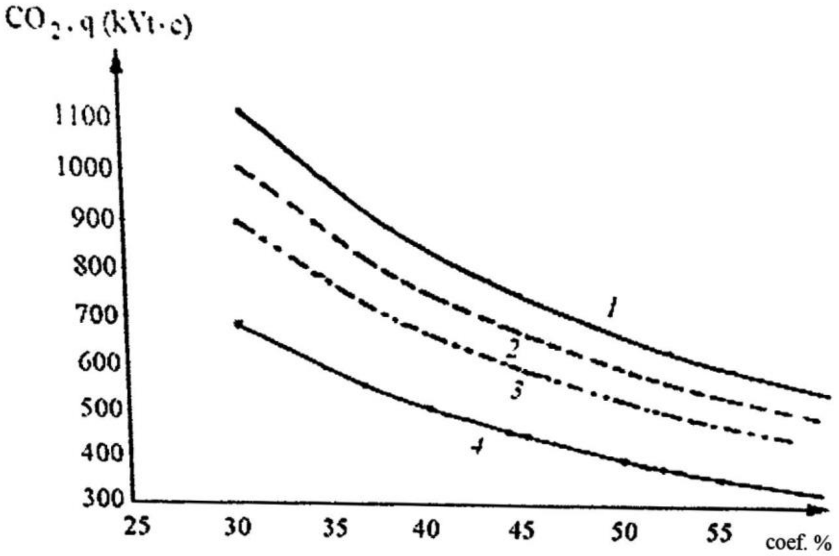
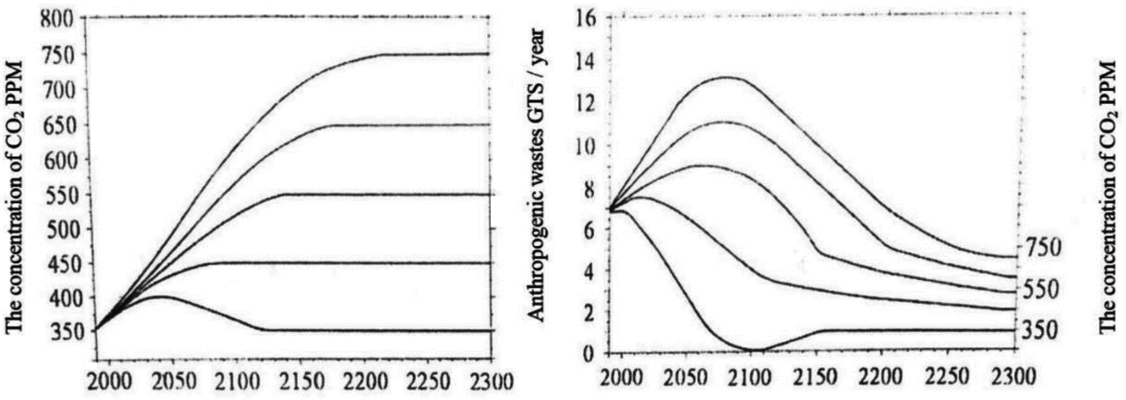


Fig. 5: *Dependence of CO_2 emitted into the atmosphere on net coefficient of performance*
1-when burning coal; 2,3- When burning biomass with coal; 4- When natural gas is burned

Fig. 5. shows that as the efficiency increases, the amount of CO_2 released into the atmosphere decreases. When burnt with coal and biomass, the amount of CO_2 emitted is the same in gas-fired power plants [1]. The greenhouse effect in the atmosphere is mainly caused by carbon dioxide CO_2, which results in climate change. Reducing carbon dioxide in the air and maintaining at least its concentration is a long process and requires a large amount of money. With stabilization of carbon dioxide in the air is shown in Fig. 6. The concentration of carbon dioxide in the atmosphere over a period of time is around 350 and 450 PPM, [2] and currently the concentration of CO_2 in the

atmosphere continues to increase. At the same time, it is predicted that if environmentally friendly technologies are used in energy production (ie from renewable energy sources, the concept of hydrogen energy, etc.), emissions of anthropogenic carbon dioxide emissions will decrease begining from 2030.



a) Forecast of atmospheric changes in the concentration of CO_2 gas up to 2300

b) Total values of anthropogenic emissions of CO_2 emitted into the atmosphere up to 2300

Fig. 6: *Carbon dioxide stabilization at 350-750 ppM in the air*

It should be noted that in the production of electricity, despite the use of non-traditional technologies, the use of natural fuels prevails. More than 60% of electricity [1] is generated by natural gas and solid fuel burning plants. Steam-turbine power plants, and combined steam-gas turbine thermal power plants. Maintly operate with gas fuel these stations have been upgraded to operate with special steam-gas power units and a combined Brighton-Rank cycle. In order to reduce the amount of CO_2 emitted into the atmosphere, it is necessary to increase the thermodynamic efficiency of energy complexes, and research is being conducted in this area. For this purpose, the issues of increasing the temperature of the gases entering the gas turbine, reducing the temperature of the gases emitted from the utility boiler are being studied. Currently, the temperature of the gases in front of the gas turbine is 1500º C [3,4], in this case it is possible to obtain a efficiency of 60%. Steam-power units operating with higher than critical parameters save 10-11% of fuel in steam-gas units compared to steam-gas units. However, by increasing the capital cost and service life, it is possible to deliver steam turbine blocks to steam-gas units due to thermal efficiency. It should be noted that the technological production readiness of steam turbine blocks operating at a critical higher parameter is very high.

Thus, it is expedient to create steam turbine thermal power plants with supercritical and ultra-supercritical parameters, which are an alternative to environmentally friendly steam-gas plants, and it is possible to increase the net coeffiecent of performance of such improved power units to 53-55%.

II. Conclusions

1. It is expedient to create steam turbine thermal power plants operating with supercritical and ultra-supercritical parameters, and it is possible to increase the net coeffiecent of performance of such improved power units to 53-55%.
2. It is expedient to develop and operate steam turbine units as an alternative to environmentally friendly combined steam and gas installations with an efficiency of 60% efficiency.

3. It has been found that the capacity and coeffiecent of performance of units operating with raise parameters increase, fuel is saved, the amount of harmful gases emitted into the atmosphere and the environmental load decreases.

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