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Alternative trends in development of thermal power plants

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Abstract

Thermal (or fossil fuel) power plants (TPP) are the major polluters of man's environment, discharging into the atmosphere the basic product of carbon fuel combustion, CO_2. It is this very gas that accounts for the greenhouse effect causing the global climate warm-up on our planet. A natural solution of the problem of reducing carbon dioxide discharge into the atmosphere lies in power saving, thus reducing the amount of the fuel burnt. This approach can be justified from any standpoint, both economically and ecologically. The ideal way of solving the problem would be to completely give up burning carbon-containing fuel, such as coal, petroleum products, and other power resources of organic nature.

This work is intended to outline the ways of reducing consumption of fuel by TPP and, consequently, of reducing their discharging into the atmosphere the gases producing the greenhouse effect. One of the ways lies in changing the thermophysical characteristics of the working medium, which becomes possible if we can modify the conventional working medium, that is water, or can use some working medium with quite different thermophysical properties. The article dwells on various technological ways providing for a practical solution of the problem, such as the Kalina cycle; modification of water properties by way of magneto-hydrodynamic resonance (MHD resonance); and employing, in the thermodynamic cycle of Thermal Power Plants, liquids boiling at temperatures which are lower than that of the environment.

Keywords: Saving power; Efficiency; Reducing discharges into the environment; Thermal power plant

1. Introduction

History of civilization and the progress in science and technology are closely associated with the growth of power consumption. A direct consequence of the developing heat power engineering based on combustion of carbon-containing fuel and of the growing amount of electric power produced is the increasing consumption of fuel-energy resources. Consuming coal, oil and gas to produce electric power, and consuming over 1% of the atmospheric oxygen, heat power engineering replaces it by SO_2, NO_x, and CO_2, which aggravates the greenhouse effect.

Let us now turn to the data published by the GAO (General Accounting Office, USA) on June 20, 2002 [1]. Electric power stations of the USA that began operating before 1972 discharged, in 2000, 59% of the sulfur dioxide, 47% of the nitrogen oxides, and 42% of the carbon dioxide of the total discharge by the fuel-fired plants, while having produced only 42% of the total electric power.

Let us resort to simple calculations to show the correlation between gaseous discharge from the newer and the old power stations in reference to the unit of their actual capacity. To do so we shall use a simple logic: if the older power stations produced 42% of the electric power obtained, the newer ones produced $(100 - 42)\% = 58\%$; if the older station discharged into the atmosphere 59% of the SO_2, the newer ones discharged $(100 - 59)\% = 41\%$, and so on for

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Nomenclature

CO_2	carbonic acid, carbon dioxide	*Greek symbols*	
E	energy	η	efficiency
G	weight	ρ	density
h'	gas enthalpy		
°K	degree Kelvin (thermodynamic temperature)	*Subscripts*	
m	mass	boil	boiling conditions
NO_x	nitrogen oxides	cold	lowest temperature
P	pressure	f	fuel
SO_2	sulfur dioxide	hot	highest temperature
T	thermodynamic temperature	k	kinetic
V	volume	Iq	liquid
v	velocity	n	normal conditions
W	thermal power	t	temperature

each of the gaseous discharges. Then at 1% of the power produced by the older stations there fall 59/42 = 1.405% of the SO_2, and so on. Let us list the resulting "gaseous discharge – power produced" ratios:

Power stations	Discharge per 1% of the electricity produced		
	SO_2 (%)	NO_x (%)	CO_2 (%)
Older	1.405	1.119	1.000
Newer	0.707	0.914	1.000

It is worth noting that the discharge of SO_2 and NO_x by the newer stations is lower than that by the older ones. Discharge of CO_2 is however comparable, which can be explained by the very nature of the system employed for producing heat energy. Since it is carbon-containing fuel that is burnt, the product of oxidizing the carbon turns out to be CO_2. It can be stated that for the last 30 years there have not been found any radical ways of reducing the discharges of CO_2 and heat – the principal causes of the build-up of the greenhouse effect on the planet and of a global climate warm-up.

2. Raising efficiency of power plants by changing thermophysical properties of the working medium

Efficiency is interpreted as the ratio of the thermal power W produced by a power plant to the amount of the fuel G_f burnt to produce the power

$$\eta = \frac{W}{G_f}. \tag{1}$$

Thus, efficiency of a power plant, for example a fossil fuel plant, can be increased by two different ways:

1. By increasing production of electrical and thermal power (W) without changing the amount of consumed fuel (G_f) [2], the way it is realized at power-producing plants employing a combined cycle: a gas turbine with subsequent utilization of the heat of the discharge gases.
2. By producing a constant amount of power (W) while consuming a reduced amount of fuel (G_f). Another way of raising the efficiency of power plants lies through changing thermophysical properties of the working medium. Theoretical analysis of this way is presented in the article [3]. Ecological aspects and natural limitations of the way are dwelt upon in the article [4]. In this paper, we will just briefly dwell upon the basic lines of investigation and the results achieved.

2.1. Changing the thermal properties of conventional working medium

From the point of view of technical realization, the easiest way to raise the efficiency of thermal power plants (TPP) is to change the thermal properties of the working medium, water, by employing magneto-hydrodynamic (MHD) resonance [3]. In its physical essence it is a method of initiating the second-order phase transition in water. This process is characterized by a change of all the properties of the water at the transition point. But with reference to thermal processes, it is the possibility of changing the heat of vaporization and the heat capacity that is of paramount importance.

The simplicity of technical realization of the method lies in that its implementation does not call for redesigning the TPP. It means that the method of using MHD resonance can be employed at any power station, be it old or new. In other words, improvement of ecological parameters of any TPP, in particular reducing CO_2 discharge, can be accomplished in the shortest time possible.

It will suffice just to correctly choose the position of mounting the devices (MHD resonators) in the feed water line of a steam generator and to precisely adjust the