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Economical and ecological assessment of hot-water boilers substitution or modernization within district heat supply systems across the Republic of Kazakhstan

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Abstract

This paper describes significance and necessity of PTVM hot-water boilers modernization and substitution by hot-water boilers with higher efficiency rates and improved ecological indexes. It also describes an analysis performed in relation to different ways of PTVM-100 boilers modernization across CIS countries, which were aimed at extension of boiler's heat efficiency period working on natural gas and fuel oil. Results of this analysis showed that the issue of ash and soot formation on convective surfaces during operation of boiler on fuel oil, which is directly connected with high exhaust temperatures of PTVM-100 furnace chamber, is still remains to be unsolved.

Designs of new hot-water boilers KV-GM-42 and KV-GM-145 with bi-radiated screens and optimized convective heating surfaces, suggested by authors of this paper, are considered to fit the old series of boilers, and allow to have efficiency rate at about 93% level. This paper contains assessment of economical and ecological effects, which are going to be used as grounds for substitution of hot-water boilers that have come to the end of their service lifetime. Assessment was performed based on current tariffs and normative acts and in accordance with statistics data across the Republic of Kazakhstan.

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Keywords: Hot-water boiler; bi-radiated screens; convective pipes pack; heating surfaces; efficiency rate; ecological indexes; economical effect

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1. Introduction

The Republic of Kazakhstan (RK) has developed district heat supply system (47% of heat consumption provided by Central Heat and Power Plants (CHPP) in most cities), truly corresponding to modern direction of such technology development in the world. [1]. However, topics about organization of efficient operation of heat supply systems in Kazakhstan, raised in 1980's, showed it's negative side during the commercializing. The number of materially and morally obsolete equipment used at CHPP and Boiler-houses increases, and demand in power units working on organic fuel (coal, natural gas, fuel oil) is high [2]. Major portion of units is represented by hot-water boilers, working on gas or fuel oil. Use of RER (solar collectors, heat pumps) in district heat supply systems is minimal.

Many hot-water boiler with average heating capacity up to 116 MW in RK have low heat efficiency rates (average operating efficiency rate of hot-water boilers does not exceed 88-89% [3]) and already reached 70% of it's wear level [4]. Low energy efficiency rates and reliability may be more obviously seen during the operation of boiler on fuel oil.

In spite of significant industrial reserves of raw hydrocarbon materials in Kazakhstan [1, 5], further use of hydrocarbon materials in energetics and, in heat supply accordingly, will be limited by obligations on decrease of CO₂ emissions within Kyoto protocol, which Kazakhstan has confirmed on March 26, 2009 [6], and by Laws of the Republic of Kazakhstan "About energy-savings and increase of energy efficiency" [7]. Therefore, nowadays there is a necessity in ways of modernization, substitution of morally and materially obsolete hot-water boilers used in district heat supply systems across the Republic of Kazakhstan, with purpose of fuel resources (natural gas, fuel oil) economy, decrease of operational and repair costs, as well as sufficient decrease of emissions and greenhouse gases release in atmosphere.

2. Analysis of latest researches and unsolved issues

Theoretical and practical researches given in works [5, 8] are dedicated to increase of economical, ecological and energy aspects of operational efficiency of boiler-houses, which use hot-water boilers and connected with them organizational and technical measures in boiler's operating conditions.

Researches performed with the use of new and more powerful hot-water boilers with improved economical and ecological indexes were analyzed in work [8, 9]. Along with that, some part of scientific issues concerned with the implementation of efficient hot-water boilers in already existing infrastructure of CHPP and boiler-houses, and aimed on increase of economical and ecological indexes with parallel increase of heating capacity and their connection with boiler's efficiency rate increase in the Republic of Kazakhstan are still remain to be unsolved.

Existing researches on economical and ecological grounds for substitution of worn boilers by efficient and powerful hot-water boilers were performed not widely enough. Heat supply by CHPPs and district boiler-houses in 25 of the most developed cities of Kazakhstan was centralized up to 79%, including heat supply by large CHPPs – up to 47%. PTVM series hot-water boilers being a part of CHPPs and Boiler-houses were designed more than 50 years ago. Nowadays there are not enough researches on assessment of economical and ecological effects which depend on increase of efficiency rate and heat capacity, in order to have grounds for systematic and planned substitution of old boilers by new hot-water boilers with average heating capacity operating on gas and fuel oil. High cost of liquid fuel in the Republic of Kazakhstan determines high production costs of heating energy and has a negative influence on economical indexes of hot-water boilers operation. However, not every region of the country is provided with units operating on gas, that's why there is a fuel oil used in boiler-houses instead. Therefore, design of highly efficient hot-water boilers operating on fuel oil, and their implementation in heat supply system is necessary indeed.

3. Main results of research

Main goal of this research is to analyze the real condition of stock of hot-water boilers with average heating capacity from 11,6 MW to 116 MW in the Republic of Kazakhstan, and to assess the economical and ecological effect of their systematic substitution. Efficiency of district heat supply concept has scientific grounds and confirmed

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