

Article

Improving Thermoacoustic Low-Temperature Heat Recovery Systems [†]

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Abstract: The existence and development of modern society require significant amounts of available energy. Combustion engines are the main sources of heat. Their operation is accompanied by the formation of large volumes of emissions, which have different temperatures and contain harmful substances ejected into the environment. Therefore, the urgent problem today is the reduction in heat emissions. This might be achieved through a reduction in the amount of these pollutants by improving primary heat engines, converting to new, alternative types of fuel, and at the same time, to carbon-free fuel. However, such measures only reduce the temperature level of waste heat but not its volume. Conventional technologies for the utilization of heat emissions are ineffective for using heat with temperatures below 500 K. Thermoacoustic technologies can be used to convert such low-temperature heat emissions into mechanical work or electricity. This article is focused on analyzing the possibilities of improving the thermoacoustic engines of energy-saving systems through the rational organization of thermoacoustic energy conversion processes. An original mathematical model of energy exchange between the internal elements of thermoacoustic engines is developed. It is shown that the use of recuperative heat exchangers in thermoacoustic engines leads to a decrease in their efficiency by 10–30%. From the research results, new methods of increasing the efficiency of low-temperature engines of energy-saving systems are proposed.

Keywords: waste heat recovery; power plants; thermoacoustic; thermoacoustic core



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1. Introduction

A characteristic feature of current times is a steady trend toward reducing the emission of so-called green gases. Currently, the greatest attention is paid to the reduction in the emissions of carbon greenhouse gases—CO₂, CO, NO_x, VOL—which requires the solution of complex technical and technological problems by the manufacturers of heat engines [1–3].

For industry, transport, and energetics, this means the need to implement more efficient production technologies and primary heat engines, the transition to new, more ecological types of fuel, including water fuel emulsions [4,5], and low-carbon and carbon-free fuels [6,7]. The practice has shown that such changes, as a rule, lead to a change in the structure of thermal emissions due to an increased share of low-temperature components [8,9].

The operation of any type of heat engine is accompanied by the emission of pollutants of various natures, which are a collection of material flows of different chemical compositions and with different temperatures. The utilization of thermal emissions is possible by the application of low-temperature economizer surfaces and well-known energy-saving systems of heating [10–12], cooling [13], cogeneration, and trigeneration. Further improvement in the efficiency of heat engines leads to a decrease in the temperature of heat emissions, particularly the exhaust gases of internal combustion engines (ICEs) (Table 1).

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