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Research Article

Mathematical Simulation of Tube Rack Thermal Shelding in A Tube Plate of Fire-Tube Boiler

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Abstract

The results of investigation of hydro- and thermodynamic processes in some parts of a fire-tube hot-water boiler are presented. The studies have been carried out using modern simulation techniques of fluid dynamics. A number of factors that can improve boiler reliability are revealed on the basis of numerical experiment results.

Keywords: *Fire-tube boiler, numerical experiment, flow parameters, thermal state, thermal shielding, compressibility, turbulence.*

Introduction

Purposes of the research

Reliability and service life of turbine – powered boilers are largely determined by operating characteristics of attachment points of heat exchanger tubes and tube sheets.

During the study of hydro and thermodynamic processes in working elements of a turbine – powered water boiler KUVI by the methods of computer simulation, it has been revealed that in attachment points of tubes, areas of local overheating in the weld area appear (Gainov A.A, 2011). A number of adverse factors such as non-optimal geometric parameters of an attachment point (thickness of a tube sheet, arrangement pitch of the tubes), unequal distribution of a gas flow over the front of a tube sheet, presence of crust and other deposits from the water chamber cavity etc. leads to the development of this process.

The consequence of local overheating is leakage of attachment points of heat exchanger tubes and tube sheets and quick breakdown of turbine – powered boilers.

One of the most effective methods of protection against the flow of hot gases to boiler's elements, including a tube sheet is thermal isolation. The preliminary work allows to offer several constructions of thermal protection elements, which are based on the use of thermal isolation material of a certain thickness.

Taking into account unequal distribution of gas flow over the front of a tube sheet, which may lead to appearing of local hot spots of overheating on tube walls in the area of rolling and welding, it has been proposed to use aerodynamically profiled protective pistons in combination with thermal isolation material. The aerodynamic shape of pistons has been developed based on the results of the mathematical modeling (Gainov A.A, 2011), in which a gap of the gas flow on the areas with sharp turns has been detected. It is known from gas dynamic theory that the suppression of flow gaps is possible in tapering channels, moreover, a smooth tapering channel can reduce gas dynamic losses at the inlet of tubes. Since a piston inevitably leads to narrowing of the channel entrance and, respectively, to the increase of losses in the tapering part, an inlet part of a piston is designed as a diffuser, its opening angle guarantees a steady flotation at a symmetric flow. The outlet part ought to provide the recovery of hydraulic drop.

Considering the given above, the following tasks ought to be investigated:

–Determination of the effect of thermal isolation thickness and protective pistons on the thermal state of attachment points;
–Determination of the effect of pistons on aerodynamic characteristics of the gas flow.

Description of a boiler–utilizer

A horizontal intensified turbine – powered water boiler –utilizer KUVI is intended for utilization heat of exhaust gases of internal combustion engines. An operating temperature of hot gases at the entrance is up to 873 K, at the outlet is 393 – 423 K. As a heated coolant both water and ethylene glycol solutions with temperatures up to 388 K can be used.

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