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IMPROVING ENERGY EFFICIENCY THROUGH MODERNIZATION OF THERMAL TECHNOLOGICAL EQUIPMENT AT THE "KVARTS" GLASS PLANT

Shaislamov Alisher Shabdurahmanovich
Boymatov Nurmuxammad Almardon o'g'li
Tashkent state technical university

Abstract

Modernization of thermal-technological equipment is one of the most effective approaches to improving energy efficiency in energy-intensive industries such as glass manufacturing. This article examines the potential for enhancing energy performance at the "Kvarts" glass plant through the modernization of existing thermal equipment. The study is based on the analysis of current operating conditions, technical state of glass melting furnaces, heat transfer systems, and control mechanisms identified during an energy audit. The results indicate that outdated equipment, insufficient automation, and limited use of modern heat recovery technologies significantly reduce overall energy efficiency. The paper proposes modernization measures including the introduction of advanced insulation materials, improved combustion control systems, waste heat recovery units, and digital monitoring solutions. The implementation of these measures is expected to reduce fuel consumption, improve thermal efficiency, and enhance the sustainability of glass production processes.

Keywords. Glass manufacturing, equipment modernization, energy efficiency, thermal-technological systems, waste heat recovery, industrial energy saving.

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Introduction

The glass industry belongs to the group of energy-intensive industrial sectors due to the continuous operation of high-temperature thermal-technological equipment. Glass melting furnaces, auxiliary heating systems, and heat transfer units consume large amounts of fuel and electricity, making energy efficiency a critical factor in production economics. In recent years, increasing energy prices and stricter environmental requirements have intensified the need for technological modernization aimed at reducing energy consumption and emissions.

At the “Kvarts” glass plant, a significant part of the thermal-technological equipment has been in operation for a long period, which has led to decreased performance and increased energy losses. Aging furnace structures, outdated insulation materials, and limited automation of combustion and temperature control processes negatively affect thermal efficiency. As a result, more energy is required to maintain stable technological regimes, increasing production costs and environmental impact.

Modernization of thermal-technological equipment offers substantial opportunities for improving energy efficiency in glass production. The introduction of modern heat recovery systems, advanced control technologies, and high-performance insulation materials can significantly reduce heat losses and optimize energy use. In addition, digital monitoring and automation systems enable precise control of operating parameters, contributing to stable and efficient process management.

The objective of this study is to evaluate the role of equipment modernization in improving energy efficiency at the “Kvarts” glass plant. By analyzing the current technical condition of thermal-technological systems and assessing the potential benefits of modernization measures, this research aims to provide practical recommendations for reducing energy consumption and enhancing sustainable industrial performance.

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Main Part

The modernization potential of thermal-technological equipment at the “Kvarts” glass plant was analyzed based on the technical condition of existing systems and the results of the energy audit. The assessment showed that a significant share of energy inefficiency is associated with outdated furnace designs, worn thermal insulation, and limited automation of combustion and temperature control processes. These factors lead to excessive heat losses, unstable operating regimes, and increased fuel consumption required to maintain technological parameters.

One of the key modernization directions is the improvement of thermal insulation of glass melting furnaces and auxiliary heating units. The replacement of obsolete insulation materials with modern high-performance refractory and insulating materials can substantially reduce heat transfer through furnace walls and roofs. This measure allows maintaining stable high-temperature conditions with lower energy input and contributes to extending the service life of furnace structures.

Another important aspect of modernization is the optimization of combustion processes. The introduction of advanced burner systems and automated combustion control enables precise regulation of fuel–air ratios, flame stability, and temperature distribution inside the furnace. Improved combustion efficiency not only reduces fuel consumption but also ensures uniform heat transfer to the glass melt, positively affecting product quality and process stability.

Waste heat recovery represents a major opportunity for improving overall energy efficiency. The analysis indicates that a considerable amount of thermal energy is lost with high-temperature exhaust gases. By installing recuperators or regenerators, this waste heat can be reused for preheating combustion air or raw materials, significantly reducing the demand for primary energy sources. Such systems contribute to lowering specific energy consumption and reducing greenhouse gas emissions.

In addition, the implementation of digital monitoring and automation systems plays a crucial role in the modernization of thermal-technological equipment.

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Real-time monitoring of temperature, pressure, and energy consumption parameters allows for early detection of deviations from optimal operating conditions and supports timely corrective actions. Enhanced automation improves process stability, reduces human error, and ensures efficient use of energy resources throughout the production cycle.

The analysis confirms that comprehensive modernization of thermal-technological equipment at the “Kvarts” glass plant can lead to substantial improvements in energy efficiency. By combining upgraded insulation, optimized combustion control, waste heat recovery, and digital monitoring, it is possible to achieve significant reductions in fuel consumption, production costs, and environmental impact. These modernization measures form a practical basis for sustainable development and long-term competitiveness of glass manufacturing enterprises.

Conclusion

The results of this study confirm that modernization of thermal-technological equipment plays a decisive role in improving energy efficiency at the “Kvarts” glass plant. The analysis demonstrated that a significant portion of energy losses is caused by outdated furnace structures, insufficient thermal insulation, inefficient combustion control, and limited utilization of waste heat. These factors collectively increase fuel consumption and reduce the overall thermal performance of glass production processes.

The findings show that targeted modernization measures, including the application of advanced insulation materials, implementation of automated combustion control systems, installation of waste heat recovery units, and integration of digital monitoring technologies, can substantially enhance energy performance. Such improvements enable more stable technological regimes, reduce specific energy consumption per unit of glass product, and contribute to lowering operational costs.

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In addition to economic benefits, modernization of thermal-technological equipment has a positive environmental impact by reducing fuel use and associated emissions. The proposed modernization approach provides a comprehensive and practical framework for increasing energy efficiency and sustainability in glass manufacturing. The results of this study can be applied not only at the "Kvarts" plant but also at other energy-intensive industrial enterprises seeking long-term efficiency improvement and sustainable development.

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