Increasing the energy efficiency of the industrial enterprise technological and mechanical equipment due to the use of converter steam

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Abstract. The article discusses the possibility of using converter steam to improve energy efficiency. The development of the authors will improve the performance of technological equipment in mechanical engineering. The problem of inefficient use of heat and loss of energy exists at mechanical engineering enterprises. In addition, environmental safety must be ensured at a high technological level. The above scientific problems are solved in this article by the authors. To solve the set tasks, scientific methods are used related to the generalization of data sets, their processing and the construction of an optimization model. In addition, variants of technical solutions at the enterprises of the energy industry are shown. To determine the long-term direction of increasing the energy efficiency of the facility, it is necessary to conduct a comparative analysis of the options. We have analyzed the use of converter steam for heating process equipment. It can be concluded that the method has mainly strengths, but since steam production has an almost constant cycle, the use of this method will not have a positive effect on eliminating problems. Prospects for using the technological solutions developed by the authors are associated with their practical application at metallurgy and mechanical engineering enterprises. It should be noted that the authors were the first to propose such a method for utilizing heat.

1. Introduction

The relevance of the study of methods for increasing the energy efficiency of an enterprise using secondary energy resources is determined by economic and technological indicators, when conducting a study on the utilization of converter steam at an industrial enterprise. The problems should include several issues, namely the utilization of converter steam. Utilization will save natural gas; besides, the cost of steelmaking will decrease. The authors would like to emphasize that the utilization of converter steam reduces the burden on the environment. Technological, political and economic factors are the main environmental factors that determine the increase in energy efficiency. The technological factor of the external environment manifests itself in the need to increase energy efficiency in case of use of secondary energy resources [1, 2]. The economic factor of the external environment is manifested in the saving of natural gas due to the use of converter steam. The use of a disposal facility may be influenced by political factors [3, 4]. They are expressed in economic sanctions, due to which problems arise with the supply of imported equipment for the utilization of converter steam, which is often more efficient than domestic products. Therefore, the consumer is forced to purchase only available units on the power...
equipment market, which may not correspond to the required parameters of energy consumption, power and quality of the output product. At the same time, a recovery plant requires large capital investments [5, 6]. This is reflected in the high cost of design work, automation work, and equipment costs. Consequently, a contradiction arises between the need to improve energy efficiency through the utilization of converter steam and the high costs of developing and purchasing equipment [7, 8]. This contradiction determines the following research problems. First of all these problems include the loss of thermal energy due to the discharge of converter steam into the environment. In addition, the disadvantages are damage to the environment and noise impact on the population. The unsolved problems of these problems determine the following goal of the research work [9, 10]. It is necessary to identify an energetically efficient way of using the thermal energy of the converter steam. To achieve the goal, it is necessary to solve the following tasks. The most necessary thing is to study the basic concepts of the theory and problems of improving the use of secondary energy resources. In addition, it is necessary to analyze the existing methods of using secondary resources, to choose the most efficient and rational method of using the converter steam. The objects of research in the research work will be existing installations for the utilization of secondary energy resources. The research subjects will be methods of improving the use of secondary energy resources [11, 12]. It is necessary to carry out research work to improve the methods of using secondary energy resources.

2. Materials and methods
The scientific methods developed by the authors are the formulation of the concept of technology, scientific substantiation of the concept, the search for technological approaches to the implementation of the concept, identification of advantages over alternative approaches, determination of the feasibility of further development of the technological concept and assessment of the risks of its implementation. The planned result is the ways and methods of applying the previously studied phenomena and the knowledge gained to solve practical problems of maximizing the operation of a power plant, the presentation of the results in a scientific and technical report on research work, the results of a computer model study. Scientific significance lies in the creation of new knowledge important for world science in the form of universal algorithms. The applied significance lies in the use of this knowledge to create software that implements the algorithm for the operation of a power plant. Scientific and technical development and simulation analysis with analytical definition of the objective function and experimental confirmation of the concept based on testing algorithms as part of the software for the control system of scaled components in laboratory conditions is planned to be carried out using the equipment of a mechanical engineering enterprise. These are proof-of-concept, software development, laboratory and field studies of individual technology elements, modeling and testing. The planned final of the research is checking the operability of software on operating power plants, the final scientific and technical report on the results of research work, patenting of technical solutions and software, publications in accordance with the assumed obligations. Scientific significance also lies in the universalization of the created solutions, which is important for the global energy industry and creates the preconditions for a significant economic effect. The applied significance lies in the replication of the created software on a global scale.

3. Results
To increase the energy efficiency, it is necessary to select and install a device for utilizing converter steam to transfer the maximum amount of heat from converter steam generated by waste heat exchangers OKG-160 to the return heating water, taking into account the observance of the temperature schedule for the heating water. Secondary energy resources are energy potential of products, waste, by-products and intermediate products generated in technological units, which is not used in the unit itself, but can be partially or fully used to supply power to other units. Recovery steam is generated in a recovery waste heat boiler. In many enterprises, steam is used as a heat carrier for technological purposes. Often steam is used for following purposes. Firstly, these are heating return water supply, heating raw water and heating of technological equipment. The problem ranking model
is used. With its help, the main problem is determined. To rank problems, one should assess the degree of importance and urgency of problem solving. The problem of heat energy losses has a high degree of importance of the solution and a high degree of urgency of the solution due to the fact that today the tendency of the Russian energy sector is associated with energy conservation [13, 14]. To identify the factors for solving the main problem and determine its genesis, a causal diagram of heat energy losses has been developed [15, 16]. The use of steam with such parameters is possible for the following needs. These are heating return network water and heating process equipment. The network water parameters are 1500 m$^3$/h of the flow rate and 0.18 MPa of pressure; temperature was 70°C. Let us base on the parameters of the converter steam and the return network water. The utilization unit must provide heating of the return network water to a temperature of 115°C with steam at a temperature of 250°C, water flow rate of 1500 m$^3$/h and steam consumption 100 t/h. To ensure heating of the return heating water to the required temperature in the recycling unit of converter steam and safe operation of the unit, excluding hydraulic shocks, a system for regulating the pressure and flow rate of converter steam and return network water is required [17, 18]. To maintain the pressure and circulate the return supply water, supply water pumps with frequency drives are required, and condensate pumps with frequency drives are needed to drain condensate from the converter steam recovery unit [19, 20]. The solutions described above lead to high costs for the design and installation of a utilization plant for heating return network water [21]. The schematic diagram of the recycling plant is shown in figure 1.

**Figure 1.** The process scheme using hot gases:
1 – gases; 2 – hot water; 3 – cold water; 4 – nozzles; 5 – water output; 6 – gas output

**Figure 2.** The new process scheme: 1 – heat exchanger; 2 – water tank

### 4. Discussion

The introduction of a waste heat boiler will significantly reduce the cost of purchasing natural gas, which is used in the production of steam and water. Also with the installation of this utilization system, the degree of purification of process gases from harmful substances will increase due to the low temperature at the gas-cleaning unit itself. Recycling of waste gas heat was not used due to the low temperature of the gases. At present, the problems of energy conservation are the main challenges in industrial production. At the enterprises of this or that industry, factories, combines there are large losses due to insufficient use of energy in technological processes. For example, the heat of the process gas generated during the production process is either not used efficiently enough, or is simply not simply emitted into the atmosphere. Such an example leads, firstly, to environmental pollution and environmental degradation in industrial and urban areas, and secondly, to extensive and unnecessary energy losses in industrial production (figure 2). A huge amount of metallurgical equipment, coupled with a large consumption of fuel and energy resources, has a rather low efficiency, which in turn leads to losses of thermal energy into the atmosphere and large economic losses of the enterprise. For example, in high-temperature metallurgical units during the production of main types of products, high-temperature process gases are formed, which can be used as fuel in heating furnaces of the plant or enterprise itself to generate electricity or hot water, superheated steam and dry air. These types of fuel resources are called secondary energy resources, the energy potential of which is in products, secondary and intermediate elements that are not used in the furnace, but can be partially or
completely used in the energy supply of secondary consumers. Secondary energy resources are divided into groups. In metallurgy, in ferroalloy production, one of the most important processes in technology is the production of alloys in high-temperature furnaces, subsequently from which technologically gases of medium or low temperature are released. For the use of waste gases from ferroalloy furnaces, take into account the fact that the gas temperatures are relatively low – 180 - 500°C.

We note the new approaches of the team of authors to the scientific problem being solved. The team forms a theoretical justification for the application of the combined desalination technology in close cooperation, which conducts modeling and begins to develop a hybrid plant for desalination of water based on the fundamental theoretical basis of the way of operation of a new technological cycle, represented by the collective in the form of a mathematical model. The partners are jointly developing a draft heat recovery and recovery scheme using the Rankine cycle, Kalina cycle and solar collectors in combination with a groundwater desalination system. Cooperation of partners is carried out in terms of registration of intellectual property, coverage of the results of the project in leading peer-reviewed international journals of the corresponding profile.

5. Conclusion
The advantage of the introduction of waste heat boilers is a significant decrease in the temperature of flue gases and, accordingly, improved filtration in the gas cleaning plant, which will lead to a decrease in the emission of fine dust into the atmosphere by 99.9%. Waste heat boilers are classified according to the following criteria. These features include the type of heat exchange in the boiler; boiler design; layout and design features of the gas-tube boiler; the presence of circulation of feed and boiler water; arrangement of the execution of gas ducts. In the near future, the installation of a new closed-type ferroalloy furnace will take place, and under which a project for the introduction of a smoke-fired waste heat boiler will be considered. The concept of the project was previously tested in the Matlab Simulink software package. The proposed control scheme in a simplified form was pre-tested with hardware. Both tests showed that it is impossible to increase the efficiency of a power plant without applying the exergy method of economic analysis. However, in order to prove the concept and further increase the efficiency, it is necessary to conduct more in-depth research and accurate modeling in combination with an increase in the accuracy and reliability of calculations with practical testing of the software to be developed in the control system of a real power plant. Over time, authors generate proof of concept proofs, fabricate individual scaled technology elements, and conduct laboratory tests of basic technology elements. In addition, scientists retain the planned final of fundamental research – the use of the developed foundations of the exergo-energetic approach to the exergo-economic method of thermodynamic analysis of low-temperature power-engineering installations. Authors present results of life cycle analysis and economic analysis of desalination system transients and optimal management strategies. At the end of the project, the partners begin to commercialize the technology in countries with the creation of prerequisites for a significant economic effect.

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