Using the heat pump in a combined sintering machine

K V Osintsev, M V Tregubova, Y A Perekopnaya, Iu S Prikhodko

South Ural State University, 76, Lenina ave., Chelyabinsk, 454080, Russia
E-mail: pte2017pte@mail.ru

Abstract. The continuous sintering machine is designed for sintering small fractions of iron ores. Also, this unit allows you to remove harmful impurities from the ore. The exhaust gases have a fairly high temperature. The heat of these gases can be used in various processes. The article proposes to use gases with a temperature above the temperature of the atmospheric air as a source of heat for a heat pump. With a certain design and technological scheme, this method of utilization can be used as a basic technological platform for the organic Rankine cycle. In addition, the circuit can be transformed into a cold supply circuit.

1. Introduction

The sintering machine is a closed chain of moving sintering palettes moving along the rails by means of a drive, and on the lower part, under the action of its own weight, three rows of grate are mounted on a steel frame. When moving along the working chain, the grate passes over the vacuum chambers connected to the exhauster. Seals prevent air suction between the carts, so that the bulk of the air passes through the mixture. Laying the layer is made by special feeders. The ignition of the charge is made using an incendiary device. The residence time of the pallet over the incendiary device is about one minute. At that moment, when the burning zone reaches the layer, the pallet enters the rounding of the discharge part, Fig.1. At the same time, the heat of the gases passing through the exhauster can not be fully used. Exhaust gas disposal methods vary. Next, we will consider some of these methods.

The authors [1, 2] consider the cycle of microelectric power, including the organic Rankine cycle. In these studies, it was shown that an increase in the efficiency of a power plant is possible only with the use of low-boiling heat carriers. In [3, 4], the authors consider similar problems, but here the solution to the problem of increasing efficiency is considered for capacities of approximately 1 MW. Improving the efficiency of the thermal power plant is possible with using the gas turbines and waste heat boilers. Thermal power plants produce in the world up to 70 - 80% electricity [5, 6]. Nowadays, besides steam turbines at the thermal power plants the gas turbine plants are used. In this case, the main equipment is a gas turbine that works on natural gas. To increase efficiency, a technological scheme uses the combined production of electricity and heat, which is supplied to consumers for industrial needs or for district heating and hot water supply. This is shown in the works of the authors [7, 8]. For this purpose steam exits of required parameters are arranged at the turbine after the corresponding stages. At the same time, much less steam passes through the condenser, which improves efficiency. Power plants of this type are called combined heat and power plants (CHP). Increased efficiency should also be achieved by increasing steam parameters [9, 10]. According to expert estimates, increasing the temperature of steam to 600°C will increase efficiency by about 5%, and the pressure increase up to 30 MPa will increase efficiency by about 3-4%. However, this will require metal with higher strengths [11, 12]. It is important
to note that in order to significantly increase efficiency, a binary cycle technological scheme using gas and steam turbines was developed.

Thus, increasing the efficiency of modern CHPs is possible only by combining the generation of heat, electricity and the main product of the plant [13, 14]. The article proposes an energy-technology complex based on a sintering machine. Thermodynamic analysis should be carried out in accordance with the recommendations of the authors [15, 16].

2. Statement of the problem. Scientific novelty
Currently, there is no technology that combines the work of a micro power plant operating on the organic ranking cycle and the agglomeration complex. This article proposes a solution to this problem. This article is the first to introduce a scheme of an agglomeration machine that combines heat and electricity generation processes. It should be noted that in this scheme low potential heat is used when the heat pump is operating.

3. The scheme of heat utilization after sintering machine
Let us consider the principle of operation of the first scheme element, which is a heat pump. Heat pumps used not only in the heating systems of private houses, but also in the heating systems of water supply network at thermal power plants are becoming more common, as this significantly reduces the cost of the generated 1 MW of thermal and electrical energy. Let us consider the principle of operation of the second scheme element, which is a solar collector. Solar energy is absorbed and converted into heat in the vacuum tubes. Heat transfer is carried out from the heat exchange rod through the sleeve to the water tank. The system kit includes pipes, an external boiler and a controller. A stable installation should be ensured. Vacuum tubes can absorb infrared rays, so the collector can work on cloudy days. The amount of solar radiation entering the vacuum collector is not subject to change due to the shape of the tubes, and therefore, in comparison with a flat collector, the vacuum tubes absorb more radiation. Sun rays fall to the surface at a right angle, thereby minimizing reflection. The collector tubes are parallel, and the inclination angle of the tubes depends on the location latitude of the installed heating system. This design may have connecting outlets on the side and back, in order to allow several collectors to be installed closely and to form a single structural system of a large area. The lateral connection is used if necessary to install structures in a row, as well as to reduce the pressure drop. The advantage of installing this type of the collector is that the tubes follow the movement of the Sun throughout the day, and if necessary you can reduce the area by removing or adding tubes, and the tubes replacement doesn't require a shutdown of the system. Vacuum solar collectors serve the house well with hot water, they are effective for ensuring the use of heat and can be used at ventilation systems of buildings and structures for various purposes. In addition, such solar collectors may well fit into the technological scheme of heating network water at a thermal power plant.

Consider the combination of the above elements with a compressed gas production system shown in Fig.2. Water 1 is saturated with triatomic gases in a special heat exchanger. Then water moves to an...
improved refrigeration-heating machine 2. Heating pipes 3 and 4 of machine 2 form reservoir 5. Pipes 3 are integrated in tank 6. Water with triatomic gases is fed into tank 6. Pipes 4 are integrated in tank 7 into which heated water 8 moves. The tank is heated by solar energy. Two tanks, namely the 6 and 7, are separated by a partition 9. The water heated in the upper tank is supplied to the chemical water treatment unit. The unit includes a main deaerator 10 and heat exchangers. From the water treatment unit, feed water enters the economizer of the boiler unit 11. The fuel could be used in the boiler unit with different characteristics [17, 18]. Here, superheated steam is generated, which is supplied to the steam turbine 12, which generates electricity in the electric generator 13. The exhaust steam 14 enters the condenser. The water flow 15 is supplied to the heat exchangers 16 of the raw water preparation unit pumped by the pump. The water must be cooled in the evaporator 17 of the refrigerating-heating machine 2. Source water mixed with some water after heat exchangers 16. The mixture flows 18 enter the absorber 19 of the refrigerating-heating machine 2, which uses the heat of gases 20 from sintering machine. The water is mixed with flue gases in the spray chamber 21.

![Figure 2](image)

**Figure 2.** Technological scheme of using the heat pump (designations are given in the text)

4. **Practical significance**

The principle scheme of the use of solar collectors and the improved bromide-lithium refrigeration machine for sintering machines using natural gas have been developed. The proposed scheme increases the agglomeration plant efficiency according to preliminary estimates by 1-2%. For the first time, an energy complex has been proposed, which allows reducing carbon dioxide emissions into the atmosphere. This technology can be used in the metallurgical and power energy industry.

5. **Conclusion**

Thus, the following scientific and practical results are identified and disclosed in the article. A technology has been developed that combines the ORC and the cycle of sintering machine in the single energy technology complex using the improved thermal transformer, namely, the refrigeration-heating machine operating in the thermal networks of the thermal power plant. In addition, it has been shown from a practical point of view that the efficiency of thermal power plant can be improved in comparison with standard schemes.

The organic Rankine cycle is most suitable for work in low and medium power ranges, usually less than a few MW, since small power stations cannot afford a local operator. Also, the cycle has a relatively simple structure and does not require components that are difficult to manufacture. Therefore, it is more adapted to decentralized power generation. The steam cycle is more suitable for high power ranges, except for low-temperature heat sources.
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