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Convective Heat Pump Dryers and Evaluation of Their Efficiency

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ABSTRACT

The article is committed to surveys of drying agrarian products using heat pump dryers; it highlights the most issues of energy saving in thermal and solar dryers. Also in this work, the issues of the application of different strategies of utilizing the heat of the squander drying agent amid convective drying of products are analyzed. Provides important data on the issue of developing energy-saving solar dryers using heat pumps, which is able, diminish energy consumption for drying fruits and vegetables and get high-quality dried products.

KEYWORDS: Convective Drying Plants, Heat Pump Units (HPU), Heat Recovery Units (HRU), Heat Pump Evaporator, Thermolabile, Recirculation, Vapor, Glycol, Heliodryers.

INTRODUCTION

The crisis in the fuel and energy complex and the rise in costs for all sorts of energy assets require the search and execution of energy-saving technologies and the ever more extensive use of renewable energy sources.

One of the foremost critical bearings of saving energy resources amid convective drying of materials is the use of the heat of the spent drying agent leaving the drying plants [1,p. 70; 2, p. 20].

A noteworthy part of cutting-edge convective drying plants is characterized by low energy efficiency. The most share of warm losses in drying plants (up to 70%) falls on losses with a spent drying agent, and therefore energy-saving measures should be pointed at lessening them or utilizing this heat for innovative needs. In addition to the widespread method of halfway distribution, more and more attention is paid to the utilize of heat pump units (HPU) and condensation heat recovery units (HRU) for utilizing the heat of squander sticky gases, in addition to the common strategy of fractional recirculation [2, p. 20].

THE MAIN FINDINGS AND RESULTS

It is known that the potential for drying the coolant in fuel-convective dryers, counting solar dryers, is not completely utilized, whereas the reuse of the heat of the spent drying agent (in the drying recirculation mode) has certain troubles, since the potential of the coolant at the outlet of the dryer is very little. In this respect, it appears promising to ponder different alternatives for utilization and recovery of the heat of the spent drying agent, the latent heat of the dried item used in the drying handle. One of the solutions to this issue is the use of heat pumps, which use low-grade energy taken from the environment [1, p. 70; 4, pp. 343-347].

The point of the study is to provide an investigation of different energy-efficient fuel and solar dryers, which utilizes the utilization and recovery of the heat of the spent drying agent during.

Recently, in the republic and abroad, more and more research is being carried out to create and progress the effectiveness of solar drying installations for drying fruits, vegetables, and other agrarian items. Within the rural divisions, there are a large number of operating solar drying plants for drying fruits and vegetables using solar energy in the CIS countries, the USA, Germany, Italy, India, and other countries [1, p. 70; 11].

The work [1, p. 70; 5, p. 336] discusses different ways to increase the productivity of drying through the use of different hardware solutions that have their own drawbacks and advantages. The most prominent impact from the use of a heat recirculation scheme with the use of an intermediate warm carrier can be obtained when drying materials with high humidity and in the presence of a spent drying agent with a tall temperature. Drying of materials with a moo dampness substance is more proficiently connected utilizing the physical heat of the dried item in recuperative warm exchangers. Dryers with a fully closed drying operator cycle have awesome openings for warm recovery. The significance of utilizing the recovery of moo potential warm of the specialist in dryers has appeared.

A method of drying with the use of heat pumps is considered, which permits using the heat of low-temperature sources, essentially increasing the thermal coefficient of drying and, in addition, processing thermolabile products. The scheme of a drying plant with a warm pump and warm recovery, as well as the thermodynamic forms that take place in it, is depicted. The coefficient of energy effectiveness of the drying plant with a warm pump has been calculated. The main headings of drying with the efficient use of warm energy are displayed and conclusions are drawn around the financial efficiency of the proposed methods of energy saving [1, p. 70].

A heat pump could be a device for transferring thermal energy from a source of low-grade thermal energy to a buyer with a higher temperature. To ensure the operation of a heat pump requires electrical vitality - this can be the most disadvantages of heat pumps [3, pp. 22 – 23; 4, pp. 343-347]. The heat pump unit (HPU) consists of a heat pump and auxiliary equipment (fans, pipelines, power supply systems, control, and regulation). Most units of a heat pump are a compressor, a condenser, an evaporator, and a choke (control valve), interconnected by a pipeline framework for circulating the working liquid. In drying plants working with a warm pump, spent heat carrier is used as auxiliary vitality assets. Warm recuperation is carried out by reverse condensation of the water vapor contained in it. In drying plants operating with a heat pump, spent heat carrier is used as secondary energy resources. Heat recovery is carried out by reverse condensation of the water vapor contained in it. The moist waste heat carrier is cooled in the heat pump evaporator to the dew point and dried as a result of moisture condensation, and then it is heated in the condenser and fed into the material to be dried, after which the process is repeated.

In work [3, pp. 22-23] a dryer with a heat pump is considered; for agrarian products, it is one of the energy-intensive forms in agribusiness. The most vitality source for drying is fuel, gas, and electricity. The cost of fuel for drying crop items is as of now much higher than the cost of developing it.

The use of heat pumps is compelling for moo temperature forms. The drying handle utilizing warm pumps is safe and naturally friendly, which makes it conceivable to utilize it in automatic mode [6, p. 600].

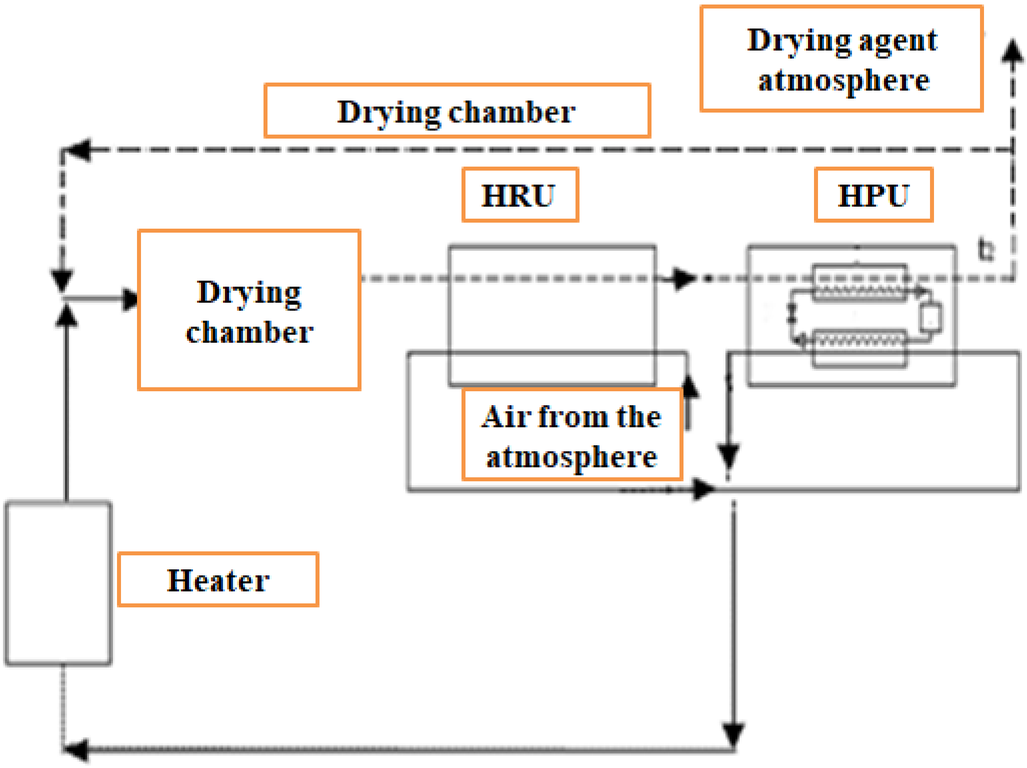

Fig. 1. Heat pump installation for drying materials, including all methods of heat recovery: recirculation, use of HRU and HPU.

The work [4, pp. 343-347] shows the advantages and economic efficiency of a heat pump dryer, and some issues related to the use of various methods of utilizing the heat of the waste drying agent. Heat losses with flue gases can be reduced by using their partial recirculation, heat exchangers-utilizers (HEU) and (or) heat pump units (HPU) (Fig. 1.). Recuperative heat exchangers are used to heat the air entering the drying chamber with a waste drying agent.

Energy reserve funds with deep utilization of heat are more noteworthy since the idle heat of condensation of water vapor frequently exceeds the sensible heat of the drying operator by a few times. Calculation of warm exchangers in such cases is more complicated and has features [6, p. 600].

With deep utilization of warm, the heat exchanger-heat exchanger works as a condensation heat utilizer (HRU). More profound cooling of the drying agent can be accomplished in warm pump installations. The evaporator of the vapor compression heat pump works as a condensing warm exchanger. This, as a rule, could be a tubular finned heat exchanger in which either a working agent (freon) or a coolant (a solution of glycol in water) moves in the tubes, and from the outside of the tube, they are washed with a moist drying agent.

The use of recirculation is the cheapest way to spare heat, but it isn't continuously conceivable and effective, since the moisture content of the drying agent increments amid recirculation and, thus, the driving force of the drying handle diminishes. Indeed if recirculation is conceivable, it cannot use all the heat of the squander gasses. The use of gadgets for profound utilization of heat extends the conceivable outcomes of utilizing distribution since it leads to a decrease in the moisture content of the drying agent. Combinations of the above methods, as well as heating using a standard air heater (or electric heater) included in the dryer, gives several dozen possible schemes for implementation. The choice of a heat recovery scheme is very important. Usually, when choosing it, two criteria are taken into account: the first is the resulting savings; the second is simplicity, which ensures reliability and ease of use. Note that the cost of equipment for heat recovery is relatively low, especially compared to the cost of fuel. On the other hand, choosing the best scheme is difficult. It depends on what kind of material is being dried, on climatic conditions and a number of other factors. An example of such a choice for drying thermolabile materials is considered in [4, pp. 343-347; 11].

To select a scheme, it is required to carry out multivariate optimization calculations. At the moment, there are certain considerations and recommendations for the organization and choice of schemes, which we will consider below.

1. The use of a heat pump is in the overwhelming majority of cases better than a simple electric heating of a drying agent, which is still quite widespread.

2. When a heat pump is used as one of the circuit elements, it should be remembered that the overwhelming majority of heat pumps can heat the drying agent to a temperature of about 60 ° C, which is often clearly insufficient. Therefore, HPU is more often used for low-temperature drying, including for drying thermolabile materials [3, pp. 22-23]. If higher temperatures are required, HPU should be used only for preheating the drying agent in front of the heater.

3. A waste heat recovery plant format with a warm pump and a waste warm exchanger is frequently way better than a basic warm pump layout since the warm pump's capacity (and subsequently it's taken a toll) is decreased. This is due to the fact that part of the warm is taken absent in the HRU. In addition, the combined utilize of HRU and HPU makes it possible to attain more profound cooling of the drying operator within the heat pump evaporator, increase the warm change proportion and decrease the cost of electrical energy per unit mass of dried material.

4. When determining the economic efficiency of the use of heat recovery in drying plants for heat pumps, it is essential to decide and use not the usual, but the total transformation ratio, warm, rise to the proportion of the heat stream transmitted to the customer within the condenser to the total electrical control consumed within the compressor and in the pumps that carry out circulation of the coolant in the evaporator and condenser circuits. Otherwise, the calculation can lead to large errors.

5. In addition to the choice of circuit solutions and the distribution of power between the components of the heat recovery system, the choice of operating parameters of the circuits is also required. For example, one of the tasks of selecting working parameters is the assignment of choosing the temperature within the HPU evaporator. The lower it is, the more moisture falls out of the drying operator, and the more seriously the heat exchange handle. However, at the same time, the HPU transformation ratio decreases. The over contemplations can be useful for the modernization of existing and for the development of new drying plants.

The information presented shows an urgent need to increase the energy efficiency of solar drying plants by using the best achievements of modern technology and technological methods, the possibility of recirculation and heat recovery of the spent drying agent and optimization of drying modes [12; 15; 17, pp. 132-136].

To solve this problem, it is necessary to study methods of increasing the energy (thermal) efficiency of heliodryers and to develop optimal designs of solar dryers using a heat pump. This can be achieved by utilization and recycling of the spent drying agent in drying units with significant enthalpy, which makes it advisable to use it as a secondary source of energy [12; 13, pp. 47 -55].

From literary sources it is known that among the energy-saving convection-type dryers, a special place is occupied by solar dryers with a heat pump designed for drying fruits and vegetables.

Based on the foregoing, it can be concluded that within the studies considered there's exceptionally small data on solar distribution dryers with a recuperative warm exchanger, as well as sun-based dryers with a warm pump. Hence, our further research ought to be pointed at expanding the energy proficiency of a recycling solar dryer of a radiation-convective sort with a recuperative heat exchanger.

In the work [13, pp. 47 -55; 14, pp. 46 -51], the device and the principle of operation of a helium dryer with a heat pump are described and the thermodynamic efficiency of the drying unit is calculated based on the energy balance and energy indicators.

The general view of the proposed helium dryer using a heat pump is shown in Fig. 2. The dryer contains, a drying chamber 1, a semi-cylindrical body 2 made of optically transparent fabric, installed in the south direction, a compressor heat pump establishment 3, with an air condenser 4 installed on the air supply line to the drying chamber 1, and a two-section evaporator, one of the section of which 5 with a blackened surface, is placed in a solar heater 6, moreover installed within the southern direction at an angle of 25-400 to the horizon, and the other section 7, made within the shape of a heat accumulator, is located in the lower part of the drying chamber on the exhaust air outlet, and sections 5 and 7 are associated in parallel.

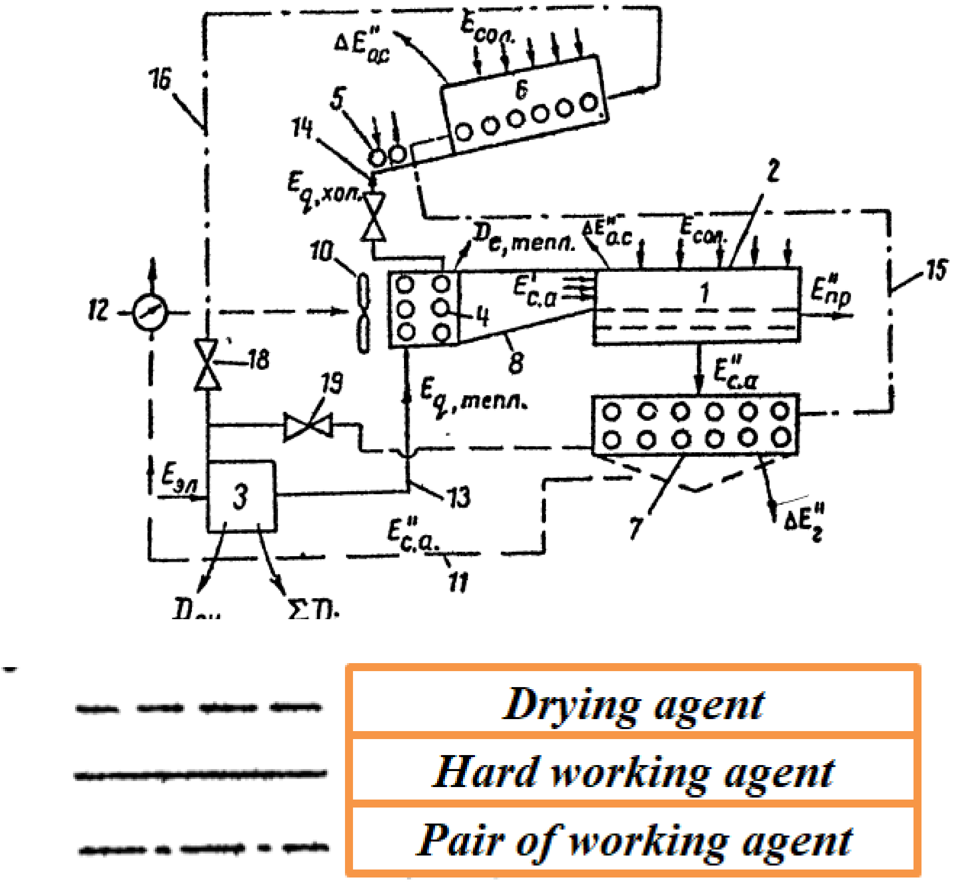

Fig. 2. Schematic diagram of a solar dryer with a heat pump.

The dryer contains an air duct 8 with a gate, a fan 10 for supplying atmospheric air to the drying chamber and a recirculation air duct 11 with a gate 12. The compressor heat pump unit is connected by a pipeline 13 with a condenser 4 and pipelines 14 and 15, respectively, with sections 5 and 7 of the evaporator, with pipelines 16 and 17 with valves 18 and 19 installed on them, respectively, as well as a drying chamber 1, an air duct through an opening in the end wall of the chamber.

A mesh is installed in the drying chamber for putting the material to be dried on it. Wet material laid on a lattice in a drying chamber, in the daytime, is dried at the same time beneath the influence of solar radiation and convection of air with a temperature of 55 - 60^{0}C penetrating the dense layer of the product.

The use of the created solar dryer with a heat pump makes it conceivable to intensify the drying handle, in comparison with solar drying 3-4 times, and in comparison with traditional convection drying 4-5 times.

In this work, the presented method of energy analysis within the study of the thermodynamic efficiency of heat pump drying plants with a solar collector allows us to determine the ways to extend the vitality efficiency of a heat pump drying plant.

The disadvantages of this dryer is a complex design, the temperature and stickiness administration of drying is not mechanized and the installation devours power. In spite of this, this plan of the dryer is promising and has a number of points of interest over other solar convection dryers. Based on this dryer, a more energy-efficient solar dryer can be designed.

CONCLUSION

Based on the research carried out on thermal and solar dryers, the following conclusions can be drawn:

1. The device and the principle of operation of energy-saving thermal and solar drying plants with a warm

pump were analyzed, and their advantages were shown in comparison with other drying plants.

2. Research and analysis of the forms of drying agricultural raw materials in dryers with a warm pump show that the use of the described methods of energy conservation will allow you to induce substantial energy savings when drying fruit and vegetable products and get high-quality dried products.

REFERENCES

1. I. V. Lakomov, Yu. M. Pomogaev. (2016) The principles of energy-saving drying technology. Voronezh State Agrarian University Bulletin.No. 1 (48). 70.
2. Garyaev A.A. (2011) Optimization of energy-saving schemes for convective drying installations for thermolabile materials. Abstract of the thesis.Diss. Candidate of Technical Sciences. – Moscow. - p. 20.
3. D.S. Kashmensky. Drying of agricultural products using heat pumps.“National Research University” MPEI, Russia, Moscow. WEB-Conference, First International Lykov Scientific Readings dedicated to the 105th anniversary of Academician A.V. Lykov. 22 - 23 September 2015
4. A. Gariaev. The use of heat exchangers and heat pumps to save energy when drying materials.“National Research University” MPEI, Russia, Moscow. WEB-Conference, First International Lykov Scientific Readings dedicated to the 105th anniversary of Academician A.V. Lykov. September, 2015. 22 – 23. – pp. 343-347.
5. Ginzburg A.S. (1985) Calculation and design of drying plants for the food industry: textbook for universities.A.S. Ginzburg.– Moscow: Agropromizdat.– p. 336.
6. Rudobashta S.P. (2010) Heat engineering. Textbook.– Moscow: Kolos.– p. 600.
7. V.I. Konovalov, E.V. Romanova, N.T. Gatapova. (2011) Drying with heat pumps in the chemical industry: possibilities and experimental techniques. Bulletin of TSTU.Volume 17.No. 1.– p. 153.
8. N.S. Kholmirzaev, V.D. Kim, B.E. Khairiddinov. Thermal balance of a solar air heater with recuperative heat exchanger.Solar technology №3, 2005.
9. V.I. Mushtaev. Drying of dispersed materials. - M .: Chemistry. 1988 352s.
10. Shazzo R.I. Low-temperature drying of food products in conditioned air: monograph / R.I. Shazzo, V.M. Shlyakhovetsky. - Moscow: Kolos, 1994 .-- 119 p.
11. http://mehanizator-ua.ru.
12. N.M. Nazarova, T.D. Zhuraev, M.R. Nazarov. Energy saving recirculating solar dryer with recuperative heat exchanger.International Scientific Conference “New Materials and Solar Technologies”. May 20-21, 2021.Parkent. Uzbekistan.
13. O.F. Safarov, D.Sh. Bazarbaeva, F. Sulaimonov.(2003) Exergy analysis of a solar dryer with a heat pump.Heliotekhnika, No. 3.– pp. 47 -55.
14. Safarov O.F., Komilov O.S., Radzhabov M.F., Abdurakhmonov O.R. (2009) An exergy analysis of a heat pump drying plant with a solar collector as a low-grade heat source. Solar technology, No. 1.– pp. 46 -51.
15. S.K. Kakhkharov, M.R. Nazarov, H.O. Zhuraev O.S. Kakhkharov “Combined solar dryer” Uzbekistan. – Tashkent. Patent for invention № UZIAP 05746.
16. G.G. Umarov, Sh.M. Mirziyoev, O. N. Yusupbekov. (1999) Heli drying of agricultural products. – Tashkent: “FAN”. – p. 378.
17. O. Rakhmatov. (2016) “On the issue of thermal optimization of the operating mode of a solar-fuel drying unit of a convective type”, Bulletin of Altai State Agrarian University No. 1 (135). – pp. 132-136.