

Compressor desalination plant based on a heat pump

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Abstract. When grain is stored, it needs to be thoroughly dried to prevent mold and insect infestations. Grain that is stored without drying can develop mold due to moisture, which can then lead to the development of mycotoxins. The drying process begins with pre-conditioning, which works to equalize the moisture content throughout the grain. This is typically done by aerating the grain with hot air, which is then circulated to ensure even drying. In summary, steam overheating is an important part of the grain drying process. It works by compressing a refrigerant gas, which increases its temperature and pressure, allowing it to absorb heat energy from the outside air. Not only does it help to reduce costs and improve the safety of the process, but it also helps to ensure that the grain is dried to precise moisture content, resulting in a more consistent and uniform product. You should leave 8 mm of space above the abstract and 10 mm after the abstract.

1 Introduction

Preserving grain for long-term storage requires controlling the temperature and humidity of the storage environment. Low temperatures and low humidity help slowly down the development of mold and decay, while high temperatures and high humidity can encourage bacterial growth. Hot air drying is one of the most effective methods of preserving grain - allowing it to last longer, require less storage space, and reduce the risk of spoilage. This process involves releasing hot air across the grain in order to evaporate the moisture, while carefully monitoring the grain's temperature, relative humidity, airflow rate, and moisture content [1, 2, 3]. While the exact temperature of the hot air depends on the type of grain, food wheat should not be heated above 55°C and seeds should not go beyond 48°C [4, 5], with food grains and seeds typically heated to temperatures ranging from 180-200°C and 100-160°C respectively [6, 7]. If the temperature and relative humidity become too high, the grain can be damaged, and the chance of spoilage increases. The airflow rate should be adjusted to ensure the moisture is evaporated while avoiding over drying, which can cause the grain to become brittle and break. The grain moisture content should be checked regularly to ensure the grain is dried to the desired level. Grain can be stored safely if its moisture content is kept

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below 13-14%. For grain with higher humidity levels, artificial drying is often used [8, 9, 10]. Present day grain dryers are usually continuous units, which come in both stationary and mobile models. Depending on the type of drying device, they can be classified as drum, shaft or pneumatic. Drum dryers are the most common type of dryers used in the industry. They consist of a rotating drum that is tilted at an angle and heated from the inside. The material is loaded into the top of the drum and is tumbled as it passes through the dryer. Shaft dryers, also known as paddle dryers, consist of a rotating shaft with paddles attached to it. The material is loaded into the top of the dryer and is agitated as it passes through the dryer. Pneumatic dryers, also known as rotary dryers, consist of a rotating drum that is heated from the outside. The material is loaded into the top of the drum and is tumbled as it passes through the dryer.

Steam overheating is an important part of the grain drying process and has become increasingly important as grain dryers are used to dry a wider variety of grains. By adding additional steam to the grain, the grain can be dried to more precise moisture content, reducing the risk of spoilage and damage to the grain due to improper drying. The installation of a heat pump can cope with this problem. A heat pump is a system which transfers heat from a source of lower temperature to a source of higher temperature. It does this by using a refrigerant to absorb heat from the outside air, which is then compressed and released into the indoor space to provide heat [11, 12, 13]. This process is continuous, allowing the heat pump to continually heat the interior space to the desired temperature. In order to ensure the highest quality grain, the grain must be dried to the proper moisture content. To achieve this, the grain must be monitored throughout the drying process, and the temperature and relative humidity of the air must be carefully adjusted. The use of steam and heat pumps can help ensure the grain is dried properly and quickly, thus reducing the risk of spoilage. With the right equipment and careful monitoring, hot air drying can be an effective method of preserving grain for longer periods of time.

2 Materials and methods. The principle of operation of the technological scheme of a grain dryer with a heat pump. Scientific novelty

The grain dryer is a tool that has been specifically designed for drying seed and feed grain of any initial moisture and clogging [14, 15]. Harnessing the power of liquid fuel sprayed through a precisely engineered nozzle, this advanced furnace generates a heat that is blended with the ambient air in the chamber, allowing for the rapid and effective drying of grain. Before being fed into the mixing chamber, the outside air passes through the heat pump. The heat pump is responsible for maintaining a consistent temperature in the grain dryer and for pulling the moist and humid air from inside the mixing chamber. The warm air is then passed through the cooling chamber where it is cooled before being recycled back into the mixing chamber. This helps to ensure that the grain is being dried in a consistent and uniform manner. Additionally, the cooling chamber helps to cut down on the energy costs associated with drying the grain. With the help of the heat pump, the grain dryer is able to maintain a temperature that is optimal for the drying of the grain.

Let us consider the operation of the compression cooling cycle in the installation according to the scheme of a heat pump, which is shown in Fig. 1. A certain refrigerant moves along the circuit of the installation. The refrigeration process begins with freon in a vapor state exiting the evaporator, where the pressure and temperature are low. From there, the refrigerant is drawn into the compressor, where its pressure and temperature are increased. The freon then passes through the condenser, where it condenses into a liquid and releases heat to the water. At the condenser's outlet, the freon is in a liquid state with a high pressure.

This liquid then passes through the expansion valve, where the pressure drops abruptly and some of the fluid evaporates into a vapor. This mixture of liquid and vapor then enters the evaporator, where the refrigerant boils, absorbing heat from the cooled space and turning back into a vapor. This vapor is then once again sucked into the compressor, completing the cycle.

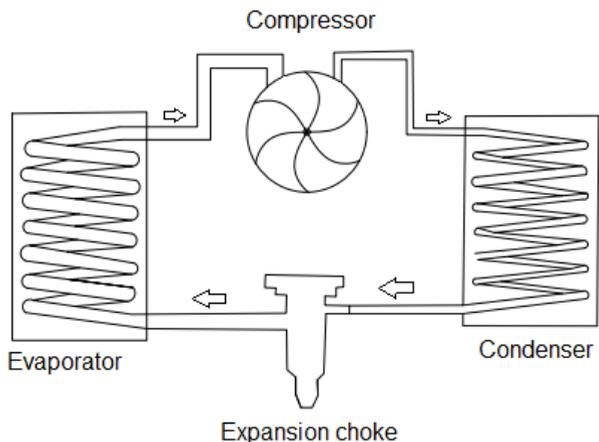


Fig. 1. Scheme of a heat pump.

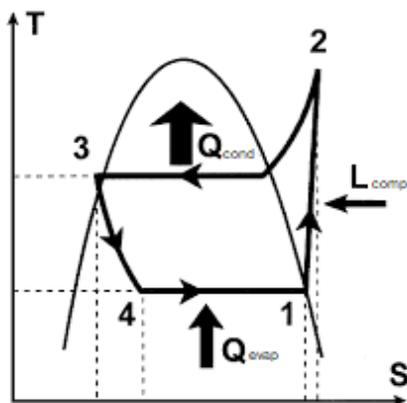


Fig. 2. Heat pump cycle: 1–2 – adiabatic compression of the refrigerant in the compressor; 2–3 – condenser heat removal for water heating; 3–4 – throttling; 4–1 – heat supply to the evaporator, T coordinates – absolute temperature; $s = dq/T$ – entropy – thermodynamic state parameter.

Thanks to the utilization of a heat pump, we can thermally elevate water up to 80 °C. In order to further enhance the temperature and vaporize water, rather than setting up another heat pump, it is more advantageous to incorporate the technological process of procuring distillate through boiling under vacuum. To achieve this, a specific apparatus will be employed, which comprises two compressors; one that will reduce the atmospheric pressure in the system, and the other to augment it. Furthermore, the apparatus has an evaporator coil, through which the preheated water will warm the incoming water [16, 17, 18].

3 Results. Practical significance

The inclusion of a heat pump in the circuit provides the following advantages.

1. Increased energy efficiency: A heat pump can provide a more efficient way to heat air for grain dryers when used in combination with flue gases. By using a heat pump to preheat the air before it enters the dryer, the need for excess fuel to heat the air is reduced. This reduces the amount of energy needed to operate the dryer, resulting in lower operating costs [14, 15].

2. Reduce emissions: By using a heat pump to preheat the air, the amount of emissions caused by burning fuel to heat the air is reduced. This helps reduce air pollution and contributes to a healthier environment [19, 20, 21].

3. A well-maintained heat pump can make all the difference in grain production. By ensuring the air flowing into the dryer is of the ideal temperature, the grain is able to be dried faster and more consistently. This leads to a greater harvest quantity, as well as a higher quality of the grain [11, 12, 13].

The installation in the fig.3 works as follows: water heated to 80 degrees Celsius enters the tank. In this tank, during the first run, the water is heated using the installed heater and the pressure is reduced to 0.47 atmospheres. The temperature of the water practically does not change, but the heat from the heater is used to transfer the water into a vaporous form. Then the steam passes through the compressor and the pressure rises, which causes the temperature of the steam to increase. The steam passing through the coil gives off its heat to the water entering the installation, and condenses itself [27, 28, 29, 30, 31].

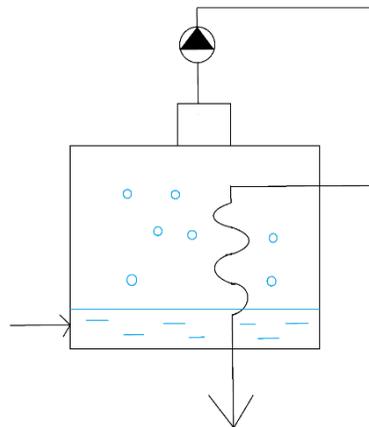


Fig. 3. Vacuum desalination plant.

The grain enters through a gravity pipe and then into a six-section drum, the blades of which pick it up and gradually move it to the unloading device.

The dried grain is channeled into the unloading conveyor via a sluice gate, and then transferred to the cooling column by a combination of a scraper conveyor and a screw. An external fan then forces the spent coolant out of the system, while a high-powered suction vent draws in a continuous stream of cool air. The grain is then transported to the space between two tightly-sealed cylinders and blown through by a powerful turbine-driven fan. Finally, the cooled grain moves back through the sluice gate and is removed from the machine via a specialized conveyor belt. [25, 26]. The machine is designed to ensure that the grain is cooled evenly and quickly, without any clumps or excess material, to ensure a consistent product quality. In addition, the system can be programmed to allow for automatic shut off after a certain period of time, to prevent overdrying or burning. The entire process is monitored and controlled by a computer, so that any irregularities in the process can be immediately addressed.

4 Discussion

The dryer is designed to efficiently dry a vast array of grains and foods with varying levels of moisture. It utilizes a furnace to burn liquid fuel, resulting in exhaust that is then mixed with fresh air to form a heated blend. This blend is sent through a heat pump, which extracts heat from the atmosphere, before reaching the mixing chamber. The grain is then scooped up by blades in a drum and slowly released into the unloading device. By combining the heat pump with the furnace, this dryer can effectively and efficiently dry grains in a cost-effective manner. This process involves pressure differences between the intake air and the heated air, as well as the use of a refrigerant gas to absorb and release the heat throughout the cycle. The air is taken in through the heat pump and compressed, increasing the temperature of the air by compressing its molecules together. This increased pressure and temperature causes the refrigerant gas to evaporate, absorbing the heat from the air [22, 23]. The dried grains is the place in a cooling column where it is moved by a scraper and a screw before being released from the machine [24, 25]. Finally, external air is plumped into the column to cool the rain before it is removed from the device [26, 27].

5 Conclusion

A heat pump can help reduce energy costs and emissions when used in combination with flue gases in grain dryers [28, 29]. The heat pump preheats the air entering the driver, which can help to increase green field and quality. Additionally, the reduced emissions caused by the heat pump result in a healthier environment [30, 31]. The process of boiling water under reduced pressure is one of the simplest and most effective methods of evaporating water and obtaining a distillate. In general, reduced pressure works well as an alternative to connecting an additional heat pump, as it is simpler and less energy intensive. Overall, the use of heat pumps and reduced pressure boiling in grain dryers can help to reduce energy costs and emissions, as well as increase green field and product quality. This is an important step in improving sustainability and environmental protection.

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