THE USE OF HUMIDITY CONTENT OBTAINED AT FRUITS DRYING

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Abstract – Climate Change in Moldova by late XXI century will manifest by the ambient temperature rises to 5.6 K and reduced water availability up to 55 %, which, on the one hand, will reduce energy consumption for heating up to 60 % on the other, will increase ventilation and conditioning consumption by over 120 %.. Water scarcity will impose strict economy of water and identifying new water sources.

It is reasonable to accumulate condensed water from fruit drying installations and its subsequent use. This process is possible to achieve in the drying device, which consists of a heat pump and solar collector.

Keywords – climate change, water, condensation relative humidity.

The evolution of climate and its impact on water availability in Republic of Moldova

According to [1 and 2], the north-west area of the Black Sea, where is Republic of Moldova, in the XXI century will be the subject of climate change is essential. The temperature will increase by 2 ... 4 K and precipitation values will decrease by 10 ... 20%. These two factors will result in reduced availability of water by 20 ... 40%, which is higher in the summer months.

The same predictions are presented in [3] are given and changes in temperature and precipitation in the country in recent decades. Figures 1 and 2, are shown in changing temperature and precipitation trends in the years 1980 - 2015. The character annual temperature increase and decrease in summer rainfall is quite pronounced.

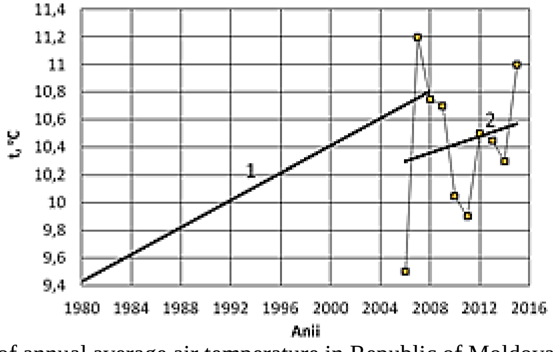

Fig. 1. Evolution of annual average air temperature in Republic of Moldova in recent decades: 1 – [3], 2 – [4].

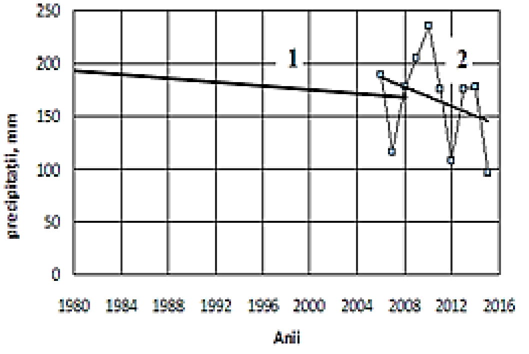

Fig. 2. Evolution of precipitations during the summer in Republic of Moldova in recent decades: 1 – [3], 2 – [4].

Tendency of temperature and water availability evolution in the country is presented in figure 3 and figure 4 as of [3] obtained after emission scenarios A2, A1B and B1 from [5]. As shown in the graphs, depending on the scenario will develop after GHG emissions in the country in the late temperature will increase by 2.0 ... 5.6 K, and water availability will decrease by 25 ... 55%. These values are even slightly higher than expected in [1 and 2].

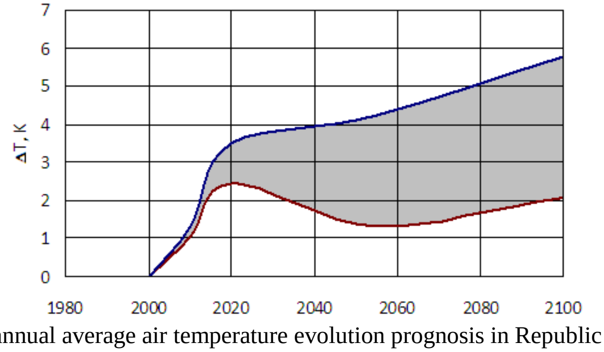

Fig. 3. The annual average air temperature evolution prognosis in Republic of Moldova in this century.

Mentioned that the outdoor temperature increase will be followed by increased water intake cooling air ventilation and conditioning systems. The issue of reducing water availability for Moldova is far more acute than the temperature increase. Currently, the standard annual consumption of water 1700 m^3 per person [6] and global consumption average of 1385 m^3 [7], Moldova consumes not less than 250 m^3 per year per person [8], the amount available it is approx. 500 m3 per year [6].

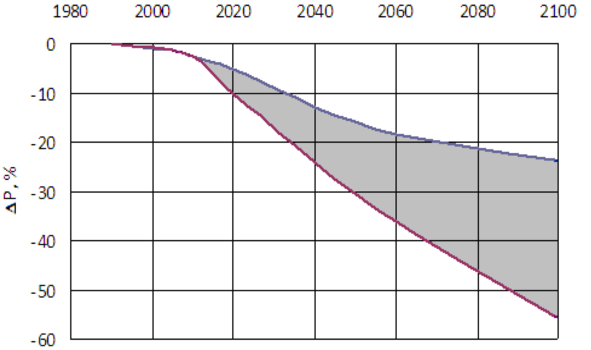

Fig. 4. The prognosis of assessment of water availability in Republic of Moldova in this century.

In contrast to the temperature rise, the positive factors reducing the availability of water does not exist, the articles of the negative impact are more [9]:

- reduction of electricity produced from hydro;
- reducing the production of biomass for biofuel production;
- increasing energy consumption in the extraction and transport of water;
- increasing energy consumption in irrigation systems;
- Problems with the availability of water in cooling energy and industrial installations.

The reduction of water availability by 55% the amount of water available in Republic of Moldova will be 225 m^3 what is under the water needs for consumption of a person. Water is an indispensable element of life requires special attention from all of us and it is necessary to use it with great care. In addition, to get just a small amount of water, we can accumulate water from condensing humidity process. The water from the hot and humid air from the drying room of fruits.

The scheme of installation for drying fruit which combine solar and geothermal energy

Drying installation uses two combined renewable energy sources: geothermal and solar. The heat pump has a high coefficient of performance thanks to geothermal energy, which is practically free and low energy consumption of the compressor. To enhance the effectiveness of the installation with heat pump drying, it is added other energy source, ecological and cheap - solar collector. Solar energy will streamline the process of reducing the load on the drying heat pump. The fruits drying regimes with high working temperature of the added surplus energy from solar collector will make lighter work schedule for the entire drying system.

This method allow to reduce energy consumption and in resulting lower costs per kg of dry product.

In Figure 5 is the optimized scheme of drying installation. The drying device is composed of the drying chamber 1, the heat pump 2, the solar collector 5, accumulator tank 6, heat exchangers, pumps and other components, which provides a qualitative and efficient drying process.

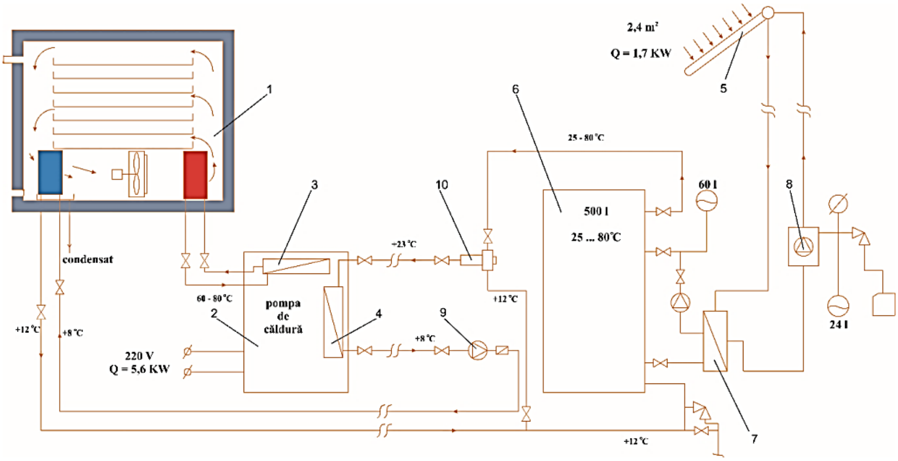

Fig. 5. The fruit drying installation scheme, which uses heat pump and solar collector as energy source

The working principle of the system consists in condensation of superheated refrigerant vapor in condenser 3, which is the necessary thermal source of the drying process. Heat escaping is directed to the drying chamber, where the heat exchanger uses the heated working agent - air. The exchange of the drying fan directs air through the heat exchanger where it is heated, after the request is directed to the product under drying. In the convective air-drying process, air stores the moisture from the product and transports it to the cold source, connected to the evaporator 4 and after heating it again, the process repeats [13].

It use water as an intermediate agent, it is cheap agent. Water provides heat transfer from the condenser to the heat exchanger (hot source), and from evaporator to the heat exchanger (cold source). Heat absorbed at the cold source, where is discharged the condensation moisture from the product is recovered and given to the condenser at vaporization process. The circulation pump 9 provides the water for the cold source. For heating agent relaxation, the contour is provided with an expansion tank. Both contours are equipped with safety valves.

The solar collector 5 connected to the heat pump drying installation, transforms solar energy into thermal energy. Heat transfer from the solar collector to heat exchanger 7 shall be working with agent - glycol solution that has work temperatures between -50°C and +250°C. The use of this agent on the entire circuit system is not profitable because of its high cost, thus using only on the sectors where the water freezes.

In installation are used tank battery 6, in which is stored solar heat collector. It provides heat supply to the heat pump during the night or on cloudy days in stock. The supply pump heating is carried out with the valve with three ways to carry out a mixing of the cold solution resulting from the evaporator to the heating tank battery resulting in a solution having a temperature of about 23 °C, which is an excess of 11 °C, which is free energy.

Collection of water from the drying fruits process.

After the drying process, the water from the product is evaporated into the air and transferred to the heat exchanger of the cold source (Figure 6). Because the operating temperature is lower than the dew point temperature, it happens humidity condensation process.

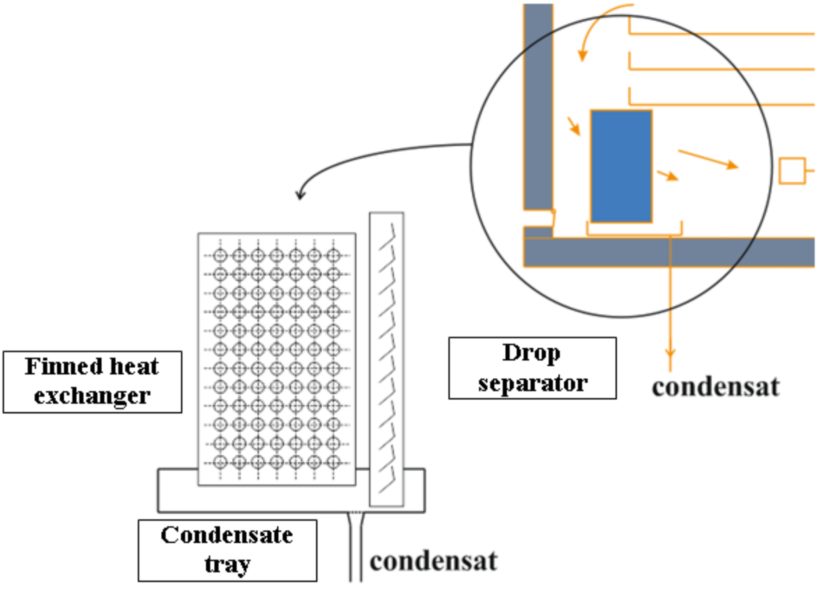

Fig. 6. Finned heat exchanger (cold source)

After condensation, the water drapes in condensate tray and here we can accumulate into a tank and use later. For a better retention of the water is used drop separator. The amount of accumulated water can be determined from the expression:

$$m_{water} = \frac{m_{cus} \cdot \varphi_{c\ in}}{\varphi_{c\ fin}} \qquad (1)$$

m_{cus} – dry body mass;
$\varphi_{c\ in}$ – the initial humidity of the product;
$\varphi_{c\ fin}$ – the final humidity of the product.

The amount of dried fruit in Moldova annually is $m_{cus} \approx 4750$ t [8, 10].

Knowing that the relative humidity of fresh apple is ≈ 80% relative humidity of the dried product is ≈ 18% the amount of water evaporated:

$$m_{water} = \frac{4750\ kg \cdot 80\ \%}{18\%} = 21111\ \text{t}$$

Thus, if we will use the drying installations capable of condensing humidity of released of the product during the drying, we can save per year 21111 tons of water.

The use of water obtained by the dry fruit drying

All known forms of life depend on water. Water is a vital part of many metabolic processes in the body. Almost 72% of fat-free body mass is water. [11] To function properly, the body requires between two to seven liters of water per day to avoid dehydration, the exact amount depending on the level of activity, temperature, humidity and other factors. Each product manufactured need water. Some industries use water more intensively than others do: 10 liters of water are used to make a sheet of paper; 91 liters are used to make 500 grams of plastic.

The use of water for nutritional purposes

The water from fruits and vegetables is very good for the body because it quickly enters into cells and slows the aging process. The key to good health is maintaining strong cells, to retain water as do young cells. Moreover, this ability of cells depends on a smooth and continuous hydration. So filtering the obtained drying condensate makes it drinkable. With the same success, we can use it as cooking water. It is also possible to use water for watering animals.

Using of condensate for technical purposes.

In food industry, water has multipurpose in processes like raw and auxiliary material; washing water; sorting water; cooling and transporting of various materials water [12]. In the case of drying installation, it can be used to wash vegetal raw materials, as well as washing appliances and containers.

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