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OVERVIEW OF SOLAR DRYERS FOR DRYING LUMBER AND WOOD

Submission Date: April 18, 2022, **Accepted Date:** April 25, 2022,

Published Date: April 30, 2022

Crossref doi: <https://doi.org/10.37547/ajast/Volume02Issue04-07>

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ABSTRACT

This paper presents the results of using solar energy for drying lumber and wood in different countries: Canada, Russia, Poland, Finland, Bulgaria, and Syria. Also described is an innovative solar dryer for drying lumber developed at the Ferghana Polytechnic Institute at the Department of Ground Vehicles and Their Operation.

KEYWORDS

Solar dryer, lumber, fans, housing, drying process, moisture, thermal conductivity, sidewalls, air slots, air, absorber, transparent polyethylene film, chamber.

INTRODUCTION

Attempts to use solar energy for drying wood are being made in England, Canada, Poland, Germany, China, France, Syria, Finland, Holland, Puerto Rico, India, Taiwan, Uganda, Philippines, Ghana, Russia, Bulgaria, Pakistan. and other states [1-7].

H. Oinas (Finland) gives the design of the dryer, which is a frame structure, in the sidewalls of which there are air slots. Above the material (shavings, straws) installed transparent films that form a ventilation air space. At the bottom, under the drying object, there is an air duct through which air is supplied by a fan. In sunny weather, transparent films roll up into tubes [8-12].

A. B. Adamovich with employees (Russia) for drying materials of plant origin (fruits, vegetables, mushrooms, medicinal plants) offer an helio dryer, which includes an air heater and a mesh tray. The air heater itself is a metal frame, which is covered with a transparent front and reflective rear and side films. An absorber is located vertically in the middle of the frame itself. The collector-absorber of radiation is made of a sheet of non-metallic heating element,

placed in a heat-resistant moisture-proof material [15-21].

S. Nikolov, I. Drozdov, N. Terziev (Bulgaria) offer a two-zone drying chamber for drying wood, into which 12 stacks (6 *1.2 *2.4 m) are loaded simultaneously with a capacity of 100 m³ of conditional material. The main element of the solar dryer is an air-type solar collector system. The upper southern transparent wall is inclined vertically at a certain angle, and the northern heat-insulating wall is located vertically. The rear sidewall is a panel sheathed in an aluminium sheet and coated in matt black. Conventionally, the chamber is divided into two main and one zone between the stacks, which provided a low-temperature drying process to a moisture content close to or below the saturation limit of wood (15 ... 20%) from the simultaneous provision of high-quality drying of the material in relation to internal stresses and plastic deformations due with a large amount of evaporated water in the initial stages of drying. Air circulates between the curved panel and the solar collector system [22-29]. The aluminium trim on the solar front wall is perforated. Supply and exhaust channels are located in the rear (northern) heat-insulated panel. Three axial fans are arranged

vertically in the stack space. There is a dampening pipe between the fans. The air circulation is two-circular [30-37]. The second, main zone, is a weakly typical periodically operating drying chamber, in which two stacks are located in pairs, where the wood is dried to a moisture content of 8 ... 12%.

In the case when the solar collector system does not provide thermal power, then an additional installation of a steam or water heater system is provided. The circulation in the last zone is carried out by 6 axial fans located horizontally [38-44]. The authors determine that the use of solar energy in comparison with steam convective dryers allows reducing fuel costs by 30% and provides, in combination (combinations) with other types of technical fuel energy, year-round operation.

M. Al-Haddat (Syria) recommends a drying chamber (38.5 *10, 2 *8.9 m) for drying, in which a tank with water (135 m³) is used to accumulate solar energy. This amount of water allows to accumulate and release daily 6.3 *10³ MJ (226 kWh) of heat at a temperature of 10 °C. To ensure a continuous drying process, additional installation of steam or water finned pipes in the drying zone is also provided when the amount of solar energy is not enough [45-52].

The chamber proposed by the author is a continuous action, two-way, 18-stack chamber with a transversely circular circulation. Stacks (4 *1.5 *3.9 m) are moved along the chamber by rollers. The dryer is oriented towards the East-West axis [53-58]. The chamber itself has an asymmetric cross-section, the size of which is regulated by the slope of the southern cover. The area of additionally installed ribbed tubes was 45 m². The productivity of the chamber with a capacity of 184.4 m³ was 7715 m³.mat./year. Heat consumption during drying from humidity 25 to 10% was 70 *10³ MJ for average annual conditions.

V. Poskorobko (Poland) for the conditions of Cape Hajnówka (53 north latitude), when the average integral radiation is exactly 340 ... 419 kJ/cm² per year, introduced a solar dryer. The heating device included a battery of solar collectors, a circulating water tank for heating tubular heaters, and instrumentation.

The chamber was provided with heat from two independent systems, one of which was designed for water, heated by solar collectors, and the other for technically saturated steam. In 4 flat collectors, double glasses were installed above the absorber, they let in solar radiation only in the direction of the absorbers. Heated water up to 90 °C. Circulated between the solar battery. It should be noted that during full insolation between 10 and 15 hours the water temperature reached 60 ... °C. It is also noted here that an oak parquet frieze 25 mm thick at an air temperature of 40 ... 45 °C reached a final moisture content of 22% in 12 days, and softwood lumber with an initial moisture content of 62% reached a final moisture content of 12 ... 15% in 9 days. The solar drying of softwood lumber was 1.5 times more compared to traditional chamber drying and 4 times less than atmospheric drying in an open warehouse in the summer.

E. Popovskaya (Poland), noting the influence of climate on the successful use of solar energy for drying wood and the positive results of such drying in Puerto Rico, India, the Philippines, the USA, and Australia, points to the expediency of using solar dryers in Central European countries. In order to obtain certain results in production conditions, two options for dryers based on solar radiation energy have been proposed. One of the dryers was a frame metal structure, which was oriented with its axis to the "east-west".

The second drying chamber of the frame structure on the southern (sunny) side was transparent and had double glazing. Beneath the glass was a solar absorber made of blackened sheet metal. The base of the chamber and its rear wall are made of heat-insulating panels. The very base of the camera is located on a turntable, which allows you to install the camera itself in the direction of incidence of maximum solar radiation using the orientation equipment. Circulation was provided by two axial fans with a power of 0.60 kW each. The capacity of the chamber was 1.8 m³, and the surface for heating and absorbing solar radiation was 6 m². M. Koberle (Germany) notes the great importance of the combination of purely atmospheric drying with solar dryers.

C.S. Young (Canada) states the expediency of using a solar dryer for the conditions of Ontario (corresponds to the conditions of Ukraine. As solar energy accumulators, the author used an ordinary river stone, with which the bottom of the chamber was covered. Depending on the time of year (Oliveira with employees (USA), using a double film as a transparent material in a solar dryer, let through 90 ... 92% of solar radiation and axial fan No. 5 for mixing heated air, dried the wood from a moisture content of 77 ... 80% to different final moisture content.

Wood drying in solar kilns in Canada. The possibility of using the energy of sunlight for drying wood was experimentally confirmed first in countries with a tropical climate (Puerto Rico, India, Taiwan, Uganda, Philippines, Ghana, Pakistan), later - in the temperate zone. In 1977-1979 experiments were carried out on the solar drying of wood in the Canadian province of Ontario (48 degrees north latitude).

Studies have shown the advantages of solar drying compared to natural drying in terms of speed and quality, as well as the final moisture content of the

wood. It was revealed that the most favourable period for solar drying in this climatic zone is summer. In 1978, boards were dried in an experimental solar dryer with an air system, which was installed at latitude 48°. A spruce board 40 mm thick, 90 mm wide and 4 m long was dried. For the first two weeks (from May 11 to June 20, 1978) solar drying proceeded more slowly than natural drying. When wood moisture reached 30%, the solar drying time did not differ from the drying time in the open air. However, within the humidity range of 30–20%, solar drying proceeded twice as fast. The authors of the experiments propose to produce solar drying to an average moisture content of 30% and only then dry the material in a traditional drying chamber.

Results of studies carried out in Poland and Czechoslovakia. The presented results served as an impetus for conducting similar studies in Poland. An attempt to dry pine boards (thickness 32 mm, width 200 mm, length 4 m) with an initial moisture content of 15% to a moisture level of 8.4% in drying chambers in the summer gave the same results as those obtained in Mountain Bavaria, then There was a success in confirming the usefulness of the solar drying method in Polish climatic conditions.

An experimental solar wood drying kiln was also constructed in Czechoslovakia. With a chamber size of 7 m³, a solar collector with an area of about 29 m² was installed with an inclination angle of 45. The experiments carried out showed the possibility of solar drying in these climatic conditions, especially drying thick hardwood boards.

The solar innovative lumber dryer was designed at the Fergana Polytechnic Institute at the Department of Ground Vehicles and Their Operation. This project is of great interest, as the local population widely uses local lumber from poplar and pine brought from

Russia in the construction of residential buildings. Numerous works have been devoted to the solar drying of lumber and wood (1-20). The lumber dryer described below was developed based on the main goals:

1. Cheap and simple design;
2. Easy operation;
3. Use of local materials.

Drying is an obligatory stage of wood preparation before processing. Furniture made from raw wood will warp or dry out and crack.

Drying lumber is a complex process. Structurally, the dryer consists of a passive solar collector, four insulated walls and a special hot floor, the roof is made of transparent polyethylene film. This solar dryer can hold up to 2 cubic meters of boards for furniture production. The dryer is heated by solar energy entering through the transparent roof and heating the air in the collector space. Air is circulated through the dryer by fans. As the heated air circulates, it absorbs moisture from the surface of the wood, which it then expels to the outside.

Heat sources in large dryers:

1. Hot steam
2. Smoke
3. Radiant heat from special devices
4. Heated rack shelves
5. Electrical current passing through wet logs.
6. Electromagnetic field of high frequency.

Chambers in large dryers operating at sawmills are equipped with basic and additional equipment:

1. Ventilation of supply and exhaust type.
2. Heat supply
3. Moisture.

Additional equipment: insulation of walls and doors. Trolleys for laying material, psychrometric equipment, and electric drive. A moisture meter is used to measure humidity. According to the method of air movement, large drying chambers are divided into:

1. With natural
2. With forced air exchange.

Large dryers differ in principle of operation

1. Convective
2. Condensation

In convective drying chambers, the wood is blown by streams of hot air, heat is transferred by convection. They can be deep tunnels or chambers. In tunnel chambers, logs are loaded from one end and dried at the other end. Drying time 4-12 hours. They work at large sawmills. By condensation drying technology, the moisture released from the material. Settles on coolers. Accumulates in containers and drains out. The efficiency of the device is very high, but the process is long and there are large heat losses.

The innovative project we have developed is very similar to a solar greenhouse. The passive solar collector provides the necessary temperature in the drying chamber, which is generated from sunlight that passes through the transparent film roof and is converted by the solar collector inside the dryer.

Many factors affect the amount of heat that can be obtained from sunlight. One is the slope of the roof, which in this design is 42 degrees south. The optimal angle of the roof depends on your location and is usually equal to the latitude of the area. One of the difficulties in choosing the optimal roof pitch is that the optimum pitch varies with the season as the angle of the sun changes throughout the year. The quality of the transparent roofing material, or glass, can also affect the amount of heat produced by the collector. Glazing should transmit the maximum amount of sunlight to the collector, and not reflect it. It must also have a certain degree of protection against destruction by ultraviolet radiation. A margin of safety to withstand the expected snow load in winter. In general, thick lumber should dry more slowly than thin lumber.

The collector area can be increased to generate more heat (for quick drying of poplar and pine, etc.). This is achieved by increasing the roof area by reducing the height of the southern wall. It is also possible to

increase the temperature by reducing the loading of the chamber with aboard.

The solar lumber dryer is built using standard techniques. The first step is to build a special hot floor. To do this, we make a table rack from steel corners, sheathe it with boards from above, the height is 50 cm, the table length is 2 meters, the width is 1 meter, we cover the entire surface of the table with a metal sheet, bend part of the metal sheet at a right angle and paint it with black matte paint. The blackened side faces south, therefore it serves as a solar absorber, due to heat conduction, and the table under the boards will be hot. We place lumber for furniture on this table, which is heated from below by solar energy. Outside the walls are painted with weatherproof paint. This project has large doors at the rear of the structure for loading, unloading and checking board samples. On the north side of the dryer, there are four ventilation openings covered with grates. The two fans used in this design are inexpensive fans with plastic blades.

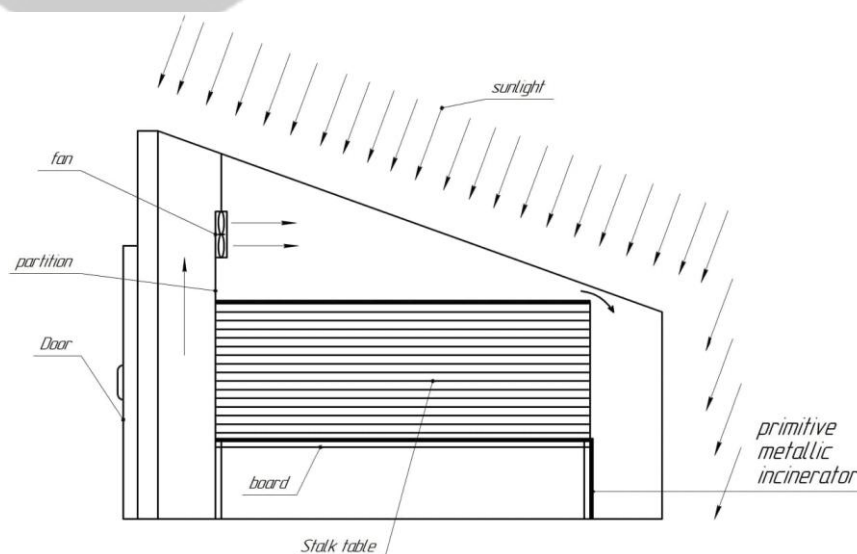


Fig.1. Lumber dryer for furniture production.

As fans, you can use kitchen ones (those that are placed on the windows). The fans are mounted on the inner wall of the dryer, 20 cm from the ceiling. An internal baffle is needed to force heated air to circulate through the lumber. If the dryer is not fully loaded, it is better to cover the distance between the internal partition and the boards with a strip of tarpaulin. This will ensure proper air circulation.

CONCLUSION

Lumber for furniture production should be stacked in the kiln in neat layers, separated by pads of narrow planks of equal thickness, with a 14 cm indent on either side of the walls - to ensure sufficient air circulation. The lumber in each layer should be the same in thickness. Raw lumber should be laid to dry shortly after sawing, otherwise, it may become mouldy, especially in the warm season.

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