Modellierung und experimentelle Überprüfung einer Pilotanlage zur solaren Holztrocknung

(Modelling and Experimental Investigation of a Pilot Plant for Solar Wood Drying)

Abstract

As means of investigation of the solar wood dryer with natural convection in Resistencia, Argentina modelling was chosen because of multiple interactions of the system, the effort of building a prototype and weather dependence of running the equipment. Comparatively short simulations may replace lengthy experiments to estimate system changes.

Modelling is based on the simulation program TRNSYS - which is in worldwide use to plan solar systems. Because of its modular structure TRNSYS is flexible and can be applied to simulate systems of many types. For the modelling of the solar wood dryer new TRNSYS components were developed to describe the wood drying process and the natural convection chimney.

Common theories of drying and technical fluid mechanics are the basis of modelling wood drying. The principal physical processes involved in wood drying are the sorption of moisture in wood, flow of moisture and heat at the drying surface, and moisture and heat transport in wood. The specification of sorption isotherms, moisture transport coefficients and further material parameters takes into account the dependence of wood drying on material values.

With the method of finite elements the local and temporal progress of moisture and temperature of wood and air throughout the staple[1] are calculated. Mean moisture content of the staple, equilibrium moisture content and drying rate may be simulated. For energetic investigations the heat flow into the wood is determined. Further outputs allow to estimate the drying quality from simulation results.

Wood drying is an important way of improving wood quality. Solar drying improves drying quality and drying rate compared to open air drying. At the same time solar drying avoids disadvantages of conventional drying, such as the dependence on fuel or electricity needed to run the equipment - implying high operating costs -, pollution caused by burning fossil fuels and high investments needed for conventional drying chambers.

The solar wood dryer with natural convection in Resistencia is entirely operated with solar energy. Air is heated in a collector resembling a greenhouse tunnel. By subsequently passing through a drying chamber with the wood stapled inside it

[1] Instead of describing the drying of a staple as a special case the drying of a single board may be investigated.

removes moisture from the drying product because of the different partial pressure of water vapor in the wood and in the air. The moist air flows through the chimney back into the environment. The chimney generates a constant airflow in the drying chamber due to buoyancy of the expelled warm air and suction caused by wind passing over the chimney. The climate at the site of the dryer in the northeast of Argentina allows year-round operating with outstanding radiation conditions and therefore high temperatures in the drying chamber.

Modelling divides the system into its main components 'tunnel collector', 'drying chamber', 'wood staple' and 'chimney'. The existing interactions of the system - flows of matter, energy and information - are transformed into equations and evaluated numerically by computer. The main simplification of the model is not to take into account the inhomogeneity and anisotropy of wood, e.g. in respect of moisture transport. The inaccuracy implied in this way in calculating wood moisture contents in the course of a simulation amounts to about 30 %.

The validation of the model was done by means of climate chamber experiments and the first drying experiment in Resistencia. In Resistencia an experimental staple of Algarrobo sawn wood from a local small sawmill was dried. Algarrobo is an abundant hardwood in the region which is mainly used for building furniture. In order to evaluate the dryer, measurements of the air condition (relative humidity, temperature and speed) were taken at different points, weather conditions (radiation, relative air humidity, air temperature and wind speed) were recorded and in regular intervals wood moisture contents of several probes were determined. With parameter identification unknown moisture transport coefficients of Algarrobo were found and inaccurate sorption isotherms were completed for modelling the drying process.

The experiments show that quick high-quality drying is feasible with the dryer in Resistencia. It takes slightly longer than conventional drying but is much faster than open air drying in the damp climate of the Chaco. Wood damage due to environmental influences or sharp drying conditions does not occur. The model describes the principal processes of wood drying satisfactorily within the estimated accuracy. The validation of the chimney has to be continued because of the insufficient number of measurements of wind speed.

The application of the model may start after its validation is completed. Besides the optimizing of existing equipment the model serves for planning and designing new systems. Especially with solar systems modelling helps to adapt to ever-changing climate, system and operating conditions. The model facilitates economic studies and informs potential users of the performance of a solar dryer. Including the model in the control of conventional dryers allows to make them more flexible to shorten drying times - at constant drying quality.

Modelling other drying processes is thinkable - based upon the wood drying model. Economic interest lies in modelling the drying of building materials and - because of the space needed for disposal - of purification mud and manure. It has to be investigated if the drying of agricultural products can be described with the help of the wood drying model.