MULTI-ADAPTIVE LOW ENERGY GREENHOUSE SYSTEM - DEVELOPMENT OF A THERMAL BLIND FOR GREENHOUSES FROM SPACER FABRICS

Jens Mählmann, Nadine Liebig, Heike Illing-Günther
[1]Sächsisches Textilforschungsinstitut e.V. (STFI), Chemnitz (Germany)

SÄCHSISCHES TEXTIL FORSCHUNGS INSTITUT e.V.

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Abstract

Awareness of a sustainable lifestyle is growing continuously, and with it the demand for regional products, especially from agriculture. In Germany, too, preference is increasingly being given to domestic agricultural products. This leads to conflicting goals, because a year-round supply requires the conversion of today's 98 % dominant outdoor cultivation to large-scale energy-intensive greenhouse horticulture. The innovative roof system ensures optimal year-round growing conditions for arable crops with minimal energy input. The individual roof elements can be assembled into modules. The system features a multi-zone and multi-layer structure.

Introductio

In Germany, vegetables are mainly grown in the open field (98 %) and only to a very small extent in greenhouses (2 %). Thus, domestic demand for vegetables in the summer months can largely be met from domestic production, while in the winter months most of the vegetables are imported [1]. To meet this increasing demand, large-scale greenhouse horticulture would be needed to provide year-round vegetable production. However, greenhouse cultivation is one of the most energy-intensive cultivation systems due to the required use of heating energy [2]. Significantly better approaches to this are offered by the Chinese lean-to construction of "no-energy" greenhouses, which are enjoying increasing interest due to their ecological and economic advantages. With insulated north, east, and west walls and a transparent south side that can be optionally insulated with straw mats to prevent heat loss, the greenhouses make extremely efficient use of incident solar energy during the day [3]. In the winter months, the temperature does not drop below zero even without supplementary heating. This project is intended to bring this highly interesting type of greenhouse to a technologically innovative stage of development in order to offer the European market an option for producing heat-loving crops with very little energy input even in winter.

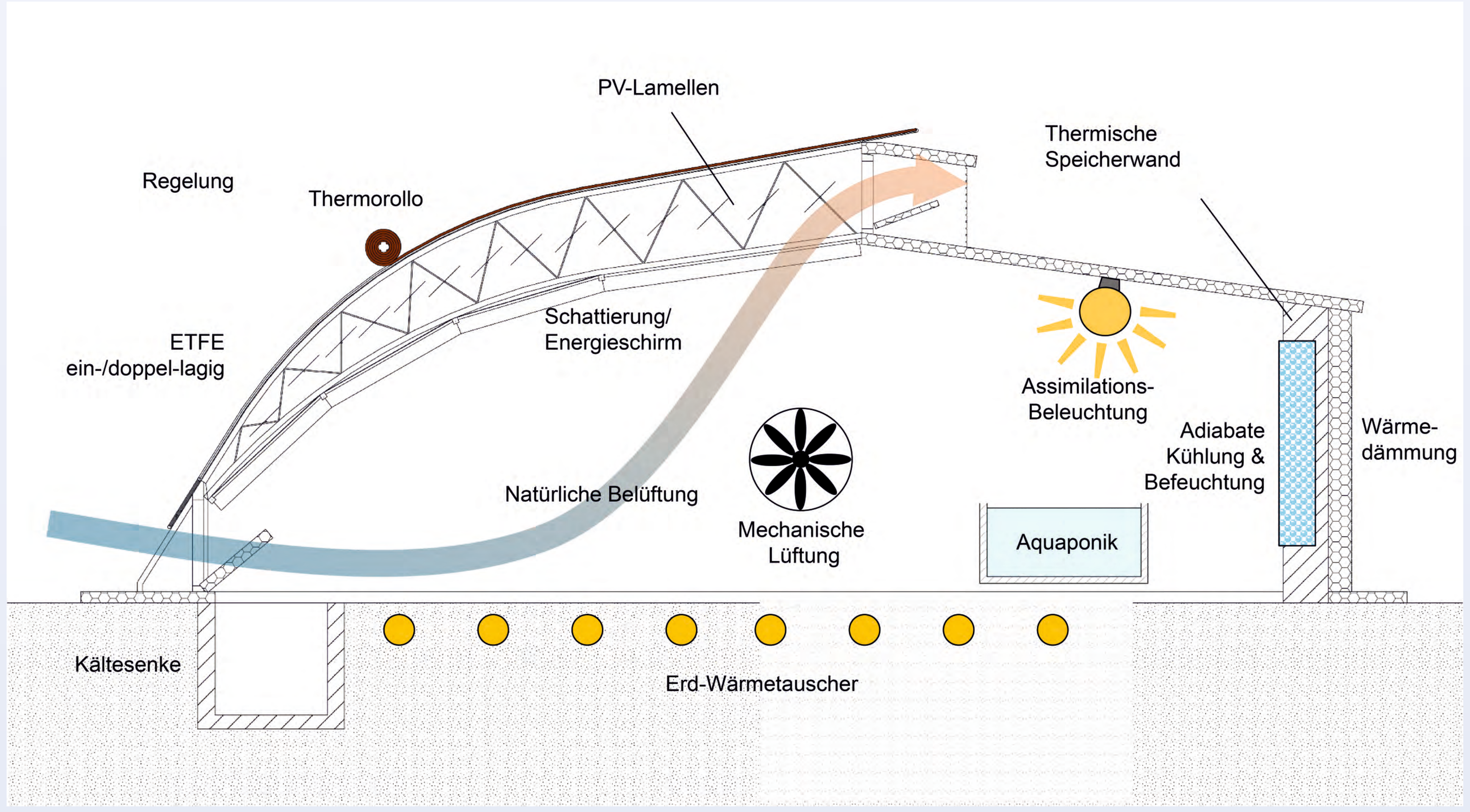

Figure 1: Multi-zone system design of a multi-adaptive low-energy greenhouse system, graphic: ebf.

Experimental

Knitted spacer structures were used for the outer insulation material. For their manufacture, PET monofilament T900W "Perlon" with a diameter of 0.20 mm, a PET low-shrinkage monofilament 900S with a diameter of 0.3 mm and later also a flame-retardant PET monofilament FR with a diameter of 0.3 mm were used as spacer yarn material. A flame-retardant PET multifilament yarn, 167 dtex f 32 x 2 z 100 semi-matte, textured, proved suitable for the cover surfaces. The yarn material was used on a conventional machine with two needle bars - a right-right raschel machine MDK 80 from Jakob Müller. The finished raw material was heat-set, flame-retardant treated and coated with the transfer coating process.

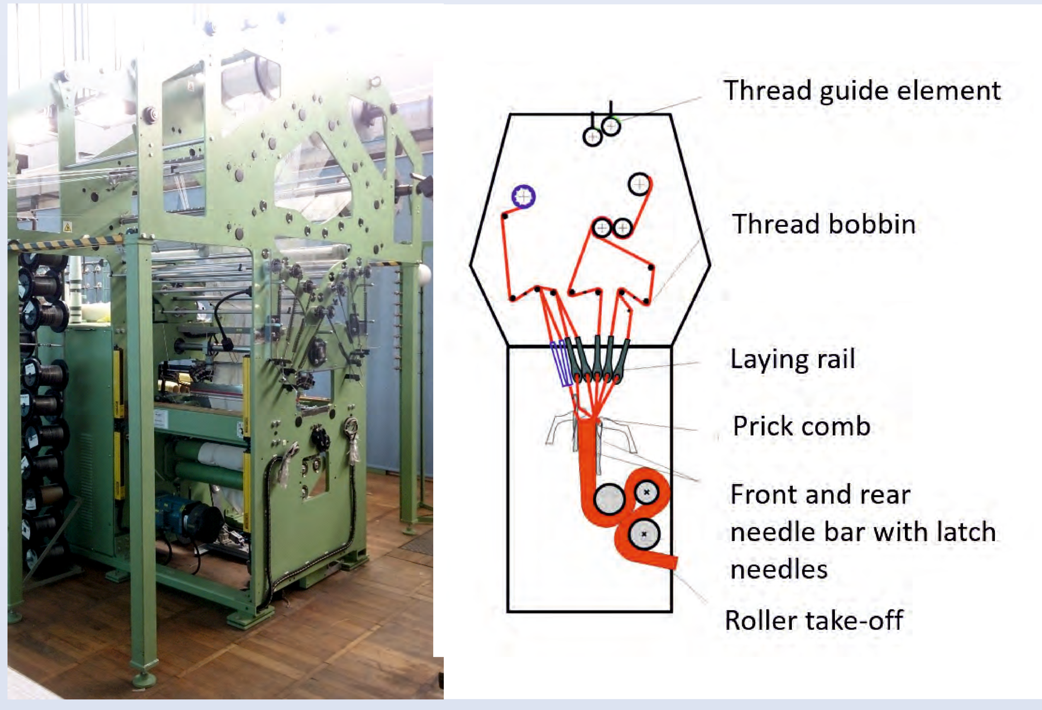

Figure 2: left: RR raschel machine MDK 80D (Jakob Müller, Frick/CH), right: Schematic of the machine with thread and material travel.

Results

Finally, the insulation effect was determined on the basis of the thermal transmittance. A measuring device with material-specific adaptations was used to determine the specific parameter. The test rig worked with radiation- and convection-related heat exchange processes inside the system under investigation. From the results, in addition to the average heat transfer coefficient (U-value), the average energy loss in kWh over a defined system area could be comparatively determined. For the calculation of the heat transfer in spacer textiles, a previously developed mathematical model was optimized [4]. This model showed agreement in principle with the experimentally determined U-values.

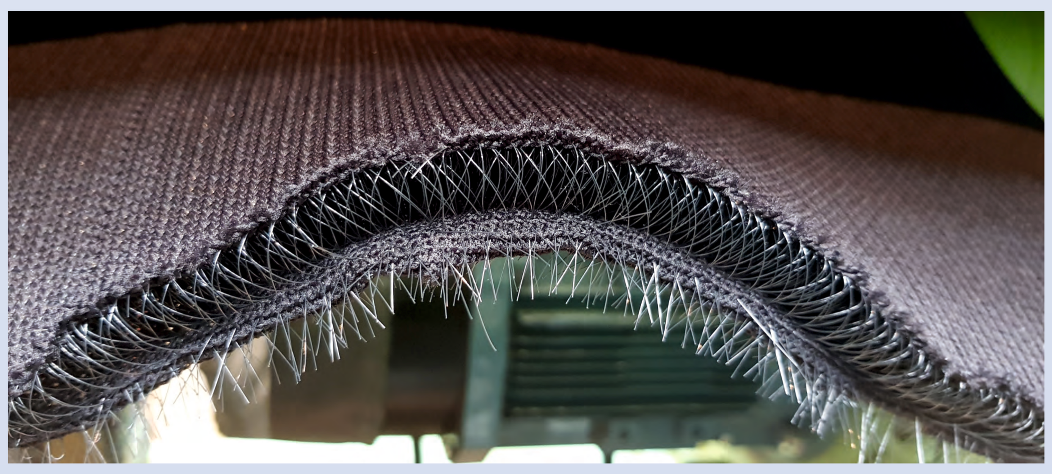

Figure 3: Cross section of a spacer fabric (#19117).

Discussion

Since the mechanisms of heat and mass transfer vary depending on the flow conditions inside and at the edges of the spacer fabrics, different results on heat transfer were to be expected in the tests despite the small differences in thickness of the test samples. This assumption was not confirmed. Neither halving the pile yarn density and thus the number of thermal bridges nor increasing the cross-section of the thermal bridges by using appropriate spacer monofilaments had any discernible effect on the thermal transmittance. A mathematical simulation confirmed the measurement. However, a tendency towards a higher insulating effect with an increase in the thickness of the spacer fabrics was discernible. In the course of systematic development, the comparative U-value was lowered from 5.66.2 $Wm^{-2}K^{-1}$ to 5.3 $Wm^{-2}K^{-1}$ by thickness expansion from 12.34 mm to 18.18 mm and changes in the structure; further reduction is expected by the coating.

Figure 4: Sample overview of the coating tests.

Summary

With the combination of the Lean-to greenhouse type and state-of-the-art functional textiles, a new type of greenhouse has been created that represents an important alternative to conventional industrial greenhouses, such as Venlo greenhouses, in the wake of resource scarcity.

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