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Design, Construction and Testing of a Solar-biomass Flatbed Dryer for Maize Cobs Drying in Rwanda

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Introduction

- Maize is one of the most important and produced cereal crops in sub-Saharan Africa.
- Drying maize remains challenging in high-altitude tropical landscapes due to unfavourable weather conditions.
- This study aimed to develop and test on-site a new solar-biomass hybrid flatbed dryer that guarantees fast and reliable drying in high-altitude Volcanic Zone of Rwanda.

Material and Methods

- The drier was conceptualized for drying maize cobs, with the design shown in Fig. 1 proving to be the most suitable.

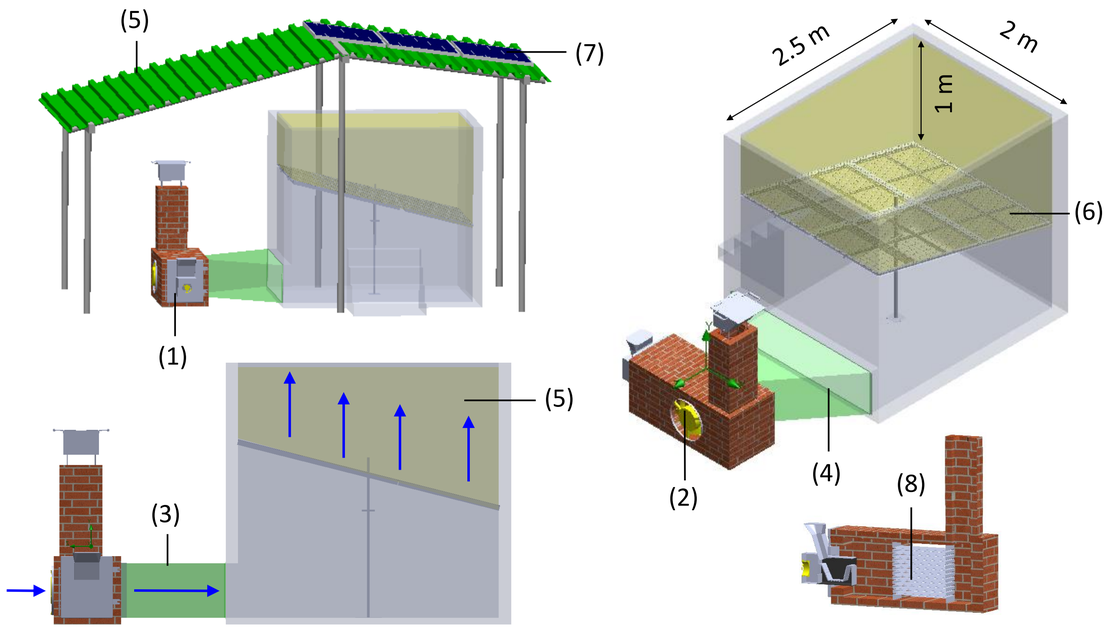

Fig. 1. CAD design of the dryer: (1) biomass combustion unit, (2) axial fan, (3) air conveying unit, (4) roof, (5) drying chamber, (6) perforated floor and (7) PV panels, (8) heat exchanger. Blue arrows indicate the direction of drying air.

- Computational fluid dynamics (CFD) simulations of the airflow were used for optimizing the dryer design and positioning/sizing the components.
- Homer Pro was used for estimating the capacity of the photovoltaic (PV) system based on local weather data.

Tab. 1. Charasteristics of the dryer

Parameter	*Value*
Drying chamber dimensions	2.5 x 2 x 1 m
Dryer capacity	2 tons of maize cobs
Burner size	0.33 x 0.23 x 0.25 m
Heat exchanger dimension	0.5 x 0.25 x 0.54 m, 22 plates
PV panels capacity	3 x 300 Wp
Batteries energy	2 x 200 Ah
Main fan diameter	0.45 m
Main fan power	220 W
Burner fan diameter	0.13 m
Burner fan power	5 W

- Cooperative Twizamure Cyuve (Long: -1.48°, Lat: 29.65°, Alt: 1880 m) provided the construction site of the dryer.
- Precision sensors were installed for monitoring in real time the temperature variation inside and outside the dryer.

Results

- From simulations, a homogeneous airflow distribution was observed in the drying bulk, which can guarantee an adequate bulk aeration and uniform drying (Fig. 2).

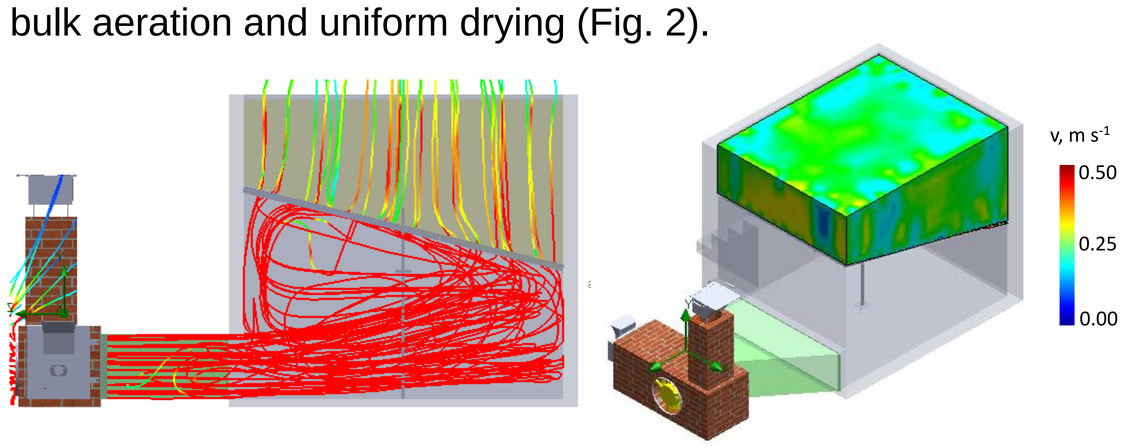

Fig. 2. Simulated airflow velocity profile for a bulk with a specific pore volume of 0.50 and inlet airflow velocity of 0.50 m s^{-1}

- The dryer was successfully constructed on-site (Fig. 3) using locally available materials.

Fig. 3. Constructed solar – biomass hybrid flatbed dryer

- Dryer was tested empty for its performance, the temperature in the plenum as well as inside the dryer was higher than the ambient temperature.

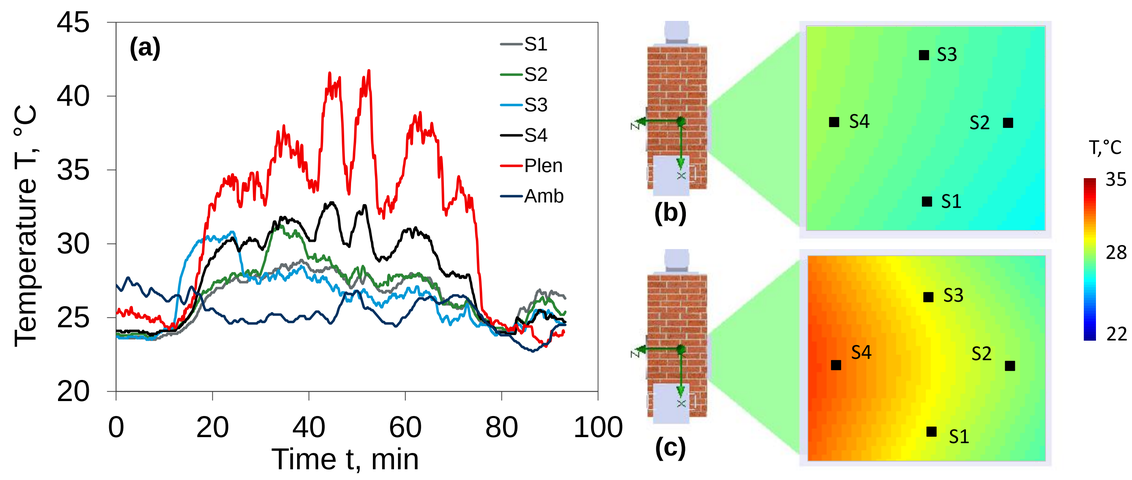

Fig. 4. (a) Temperature variation over time; spatial variation of temperature at 0.2 m above the perforated floor for **(b)** beginning and **(c)** end of the test.

Conclusion

- The newly developed dryer proved to be viable alternative to smallholder farmers compared to the existing drying methods which guarantees faster, reliable and affordable drying leading to less postharvest losses.
- The dryer performance should be further assessed for different operating and weather conditions.

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