Optimizing a Foldable Solar Cooker with Enhanced Thermal Properties for Humanitarian and Refugee Camp Deployment

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Extended Abstract

Humanitarian and refugee camps generally rely on inefficient and unsustainable cooking methods for preparing food and boiling water, such as intensive use of firewood. Due to this, the communities are contributing to deforestation and suffering health issues from inhaling the smoke (Demissie et al., 2024; Lahn & Grafham 2015). It is crucial to shift toward sustainable and efficient cooking technologies to resolve these problems. Providing clean and easy-to-use cooking systems should be seen as a humanitarian need, allowing organizations to meet their responsibilities effectively. Solar cookers offer an efficient and environmentally friendly alternative that can prevent these harmful effects on health and the environment. They play a central role in decreasing reliance on firewood and fossil fuels, reducing smoke exposure, and improving the well-being of camp residents.

In previous works by Regattieri (2016) and Mahavar et al. (2012), which also include a paper presented by Demissie et al. (2024), the potential benefits of solar cookers in humanitarian contexts have been emphasized.

In particular, a foldable solar cooker that ensured advancements over existing solar cookers was proposed in the previous study (Demissie et al., 2024). However, some issues remain concerning its thermal performance, portability, and usability. This study seeks to overcome these drawbacks by presenting an improved prototype with enhanced thermal performance and complete portability. By integrating features such as black coating inside the cooking chamber, cork insulation, and a fully foldable and lockable design, the improved solar cooker offers a practical solution for extensive deployment in humanitarian settings.

Indoor lab tests without load were carried out on the original and improved prototypes shown in Figures 1 and 2, using a metal halide solar simulator (Colarossi et al., 2021). The simulator produced a constant irradiance of about 850 W/m² during the tests. The room and stagnation temperatures were recorded with T-type thermocouples and a Pico-Technology TC-08 datalogger. The effectiveness of both prototypes was determined by calculating the first figure of merit (F_1). As shown in Figure 3, the upgraded prototype achieved a stagnation temperature of 144.63°C compared to 109.44°C for the original prototype. Consequently, F_1 of the original and improved prototypes were 0.1 and 0.14°C m²/W, respectively. These results highlight a performance improvement due to design enhancements.

The improved prototype boasts upgrades also over the design of the original solar cooker. Unlike the original prototype, the enhanced solar cooker has reflectors supported by ropes without requiring external components, as shown in the open configuration depicted in Figure 2a. As evident in Figure 2b, all components, including reflector panels, glass mirrors, and corks, can be conveniently stored inside the unit due to its design. This compact design ensures transportability and a secure locking mechanism while relocating the device from one place to another.

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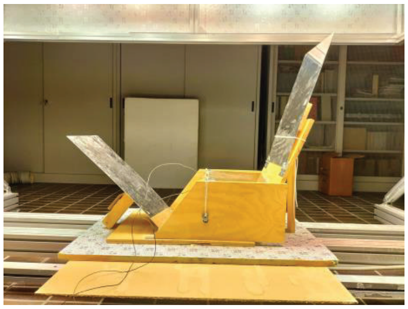

Fig. 1. Original foldable solar cooker

Fig. 2. Improved prototype: a) open configuration and b) closed configuration

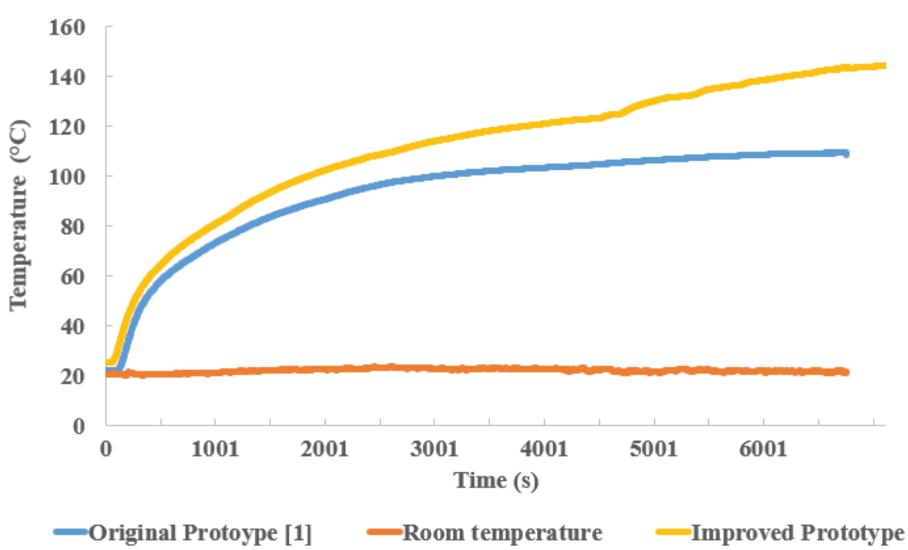

Fig. 3. Stagnation temperature of prototypes tested without load and at a constant irradiance of 850 W/m².

Keywords: Solar cooker, humanitarian camps

Conflict of Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Matteo Muccioli, Claudia Paciarotti, and Giovanni Di Nicola have a patent for a Removable, Resealable and Transportable Box-Type Solar Oven.

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