ABSTRACT

The Natural Convection Flat-Plate Collector Solar Cooker with Short-Term Storage

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One of the major problems with solar cookers is lack of storage rendering cooking at nights or early mornings impossible. The Natural Convection Flat-Plate Collector Solar Cooker with Short-Term Storage is designed taking into consideration some of these problems. This cooker also has the possibility for the spatial separation of the collector and the cooking chamber.

A double-glazed flat-plate collector of dimensions 1.85m x 0.91m covered with a selective surface - Maxorb® foil - is used as the power source for the solar cooker. Coconut oil (derived from the fruit of *Cocos nucifera*) serves both as the heat transfer fluid as well as the heat storage medium. Coconut oil was chosen because it is non-toxic, it possesses good thermal properties, it is relatively inexpensive and is produced locally. Gas Chromatography experiments show that coconut oil can be safely used in the cooker for at least one year without significant changes in its thermal properties due to oxidation and polymerisation.

At the highest part of the thermosyphon loop is an oil bath in which two cooking pots are immersed to facilitate good heat transfer between the working fluid and the cooking pot. For simplicity, circulation is by natural convection; there are no pumps in the system. Without reflectors, temperatures of approximately 140° C can be achieved between 12:00 hr and 14:00 hr under

insolation conditions of 25 $MJm^{-2}day^{-1}$ with a peak value of 1000 Wm^{-2}. The installation of two reflectors along the sides of the collector increases the effective collector area thus significantly improving the temperature output and heat storage capacity. Temperatures of about 160°C can be achieved under insolation conditions similar to those described above. With the use of the reflectors and tracking of the sun at least every hour, cooking times are significantly reduced.

Although the temperatures achieved do not permit frying, a wide variety of foods has been successfully cooked / broiled using the cooker. Investigation has shown that the cooker can also be used for drying small quantities of some food crops for domestic use.

Computer simulations performed have shown that the cooker, with some modification, can be employed in other locations around the world. Simulations can lead both to large-scale and small-scale models of the cooker. The data generated is useful in predicting long-term performance and investigating the economic feasibility of such solar energy systems.

Heat transfer equations describing heat and mass transfer along the collector were set up. The model yielded an analytical solution for the system with quantitative indications of the behaviour of the system comparing favorably with experimental results.

Keywords: Solar Cooker; Flat-Plate Collector; Natural Convection; Reflectors; Coconut Oil; Gas Chromatography; Heat and Mass Transfer and Heat Storage.