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Solar cooling for Mediterranean region as a crop storage technology

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Abstract

The Mediterranean region is a major supplier of fruits and vegetables to Europe. Fruit harvesting continues the year round, including certain fruits to be harvested from September to June. The follow up of the specific temperature and humidity storage conditions becomes significantly energy intensive that adversely affects the energy balance of exporters, especially when the producing country is run out of affordable energy sources. In order to reduce the energy costs during the crop storage and avoid the crop wastage, the solar ejector cooling systems were introduced. These systems developed recently, are fully autonomous, does not contain mechanically moving parts, reliable and durable in performance. In addition, the new type of thermopump with high energy and performance characteristics was elaborated and tested within the ejector cooling system, driven by the imitated low-grade heat. The results of theoretical and experimental study of the thermopump and the ejector refrigeration system were described in the study along with factors that affect the system's efficiency.

The crop storages operating regimes were reviewed during the storage season for the selected products. Temperature ranges defined for systems with constant area ratio ejector at COP values remains stable. Cold accumulators or duplicate conventional systems, applied during the night were considered as backup systems, supporting a non-stop operation.

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1. Introduction

The commercial scale fruit and vegetables production is often carried out in regions of a high solar radiation activity and Mediterranean Sea coast is among them.

Nomenclature

G	mass flow rate (kg/s)
p	pressure (kPa)
f	section area (m^2)
Π	relative pressure
a	sound speed (m/s)
k	adiabatic index
v	specific volume (m^3/kg)
Q	heat load (kW)
T	temperature (K)
t	temperature (°C)

Subscripts

wf	working fluid
crit	critical parameter
Cp	specific heat capacity (kJ/(kg K))
gen	generation parameter
cond	condensation parameter
eva	evaporation parameter

At the same time, the crop storage process is always energy intensive that increases the production costs and affects the competitiveness. The power supply in Mediterranean region is no uniform by countries and is always in a shortage due to the fossil nature of the most popular energy sources. Bearing in mind the high production scale and significant cooling capacity required for the crop storage provided by the electrical cooling devices, it is a perfect scope for renewable energy sources utilization, such as solar thermal, to preserve the electrical power for other economical needs.

The last decade strategy was focused on centralization policy for crop plantations. It led to small farms smashup due to electricity consumption for storage purposes that is a critical pricing factor. In order to survive, small producers have to search for an opportunity to use alternative and cheap energy systems to operate crop storage facilities for their competitive positioning and growth on the market. The latest researches present the Solar Ejector Refrigeration System (SERS) for such small crop producers. Having a number of important advantages such as simplicity in design and operation, high reliability and durability, it can accommodate almost entire crop storage requirement during the peak loads and save thousands of kilowatts of electrical power to match, preventing from CO_2 and other green house gasses emission. Interestingly, that the higher solar intensity corresponds to the higher cooling capacity demand making solar cooling technologies viable for application and energy efficient.

2. Theoretical and experimental study of the autonomous Ejector Refrigerating System (ERS)

One of the main challenges of the ERS wide expansion is a problem to feed a high-pressure vapor generator with the nearly saturated liquid. The latest achievements resolve this problem in a very reliable way [1-7]. In a result, the ERS with thermopump was built, which operates by using a part of the vapor from vapor generator (Fig. 1) [6,7].