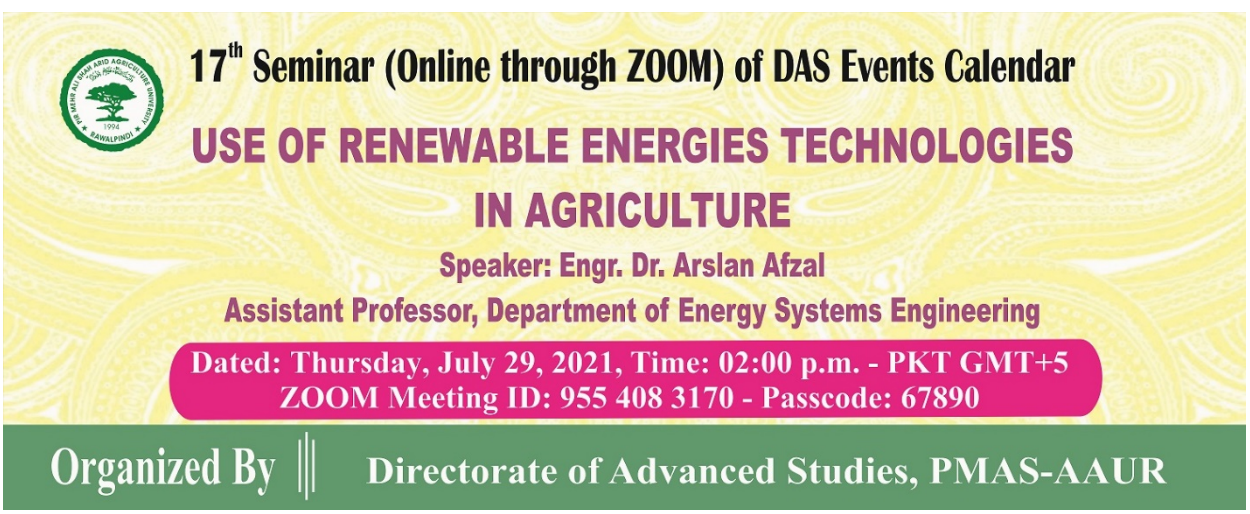
DIRECTORATE OF ADVANCED STUDIES
EVENT CATALOGUE
2021

17TH SEMINAR OF DAS EVENTS CALENDAR – 2021

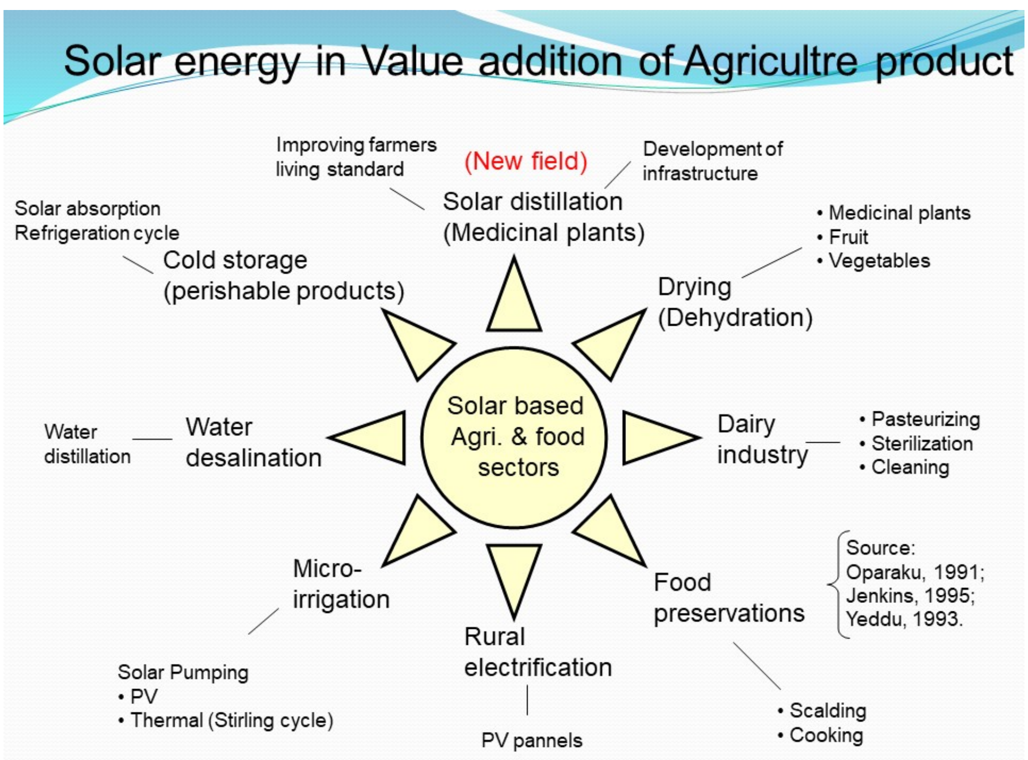
USE OF RENEWABLE ENERGIES TECHNOLOGIES IN AGRICULTURE



ACTIVITIES

Introduction

- Reserves of fossil fuels ⟶ 40 to 60 years
- 24 % of all industrial heat ⟶ < 180 °C
- Process temperature ⟶ < 180 °C
- Agro-based industries ⟶ medium temp range



- Sun is the ultimate source of energy for existing life on earth
- Solar is the most reliable energy source
- Solar energy
  - PV
  - Thermal
- Average insolation rate
  - 5.3 $kWhm^{-2}$ per day (Pakistan)
  - 1.2 $kWhm^{-2}$ per day (Europe)

Solar distillation System

Why Scheffler solar concentrator used for solar distillation system?

Non-concentrating:

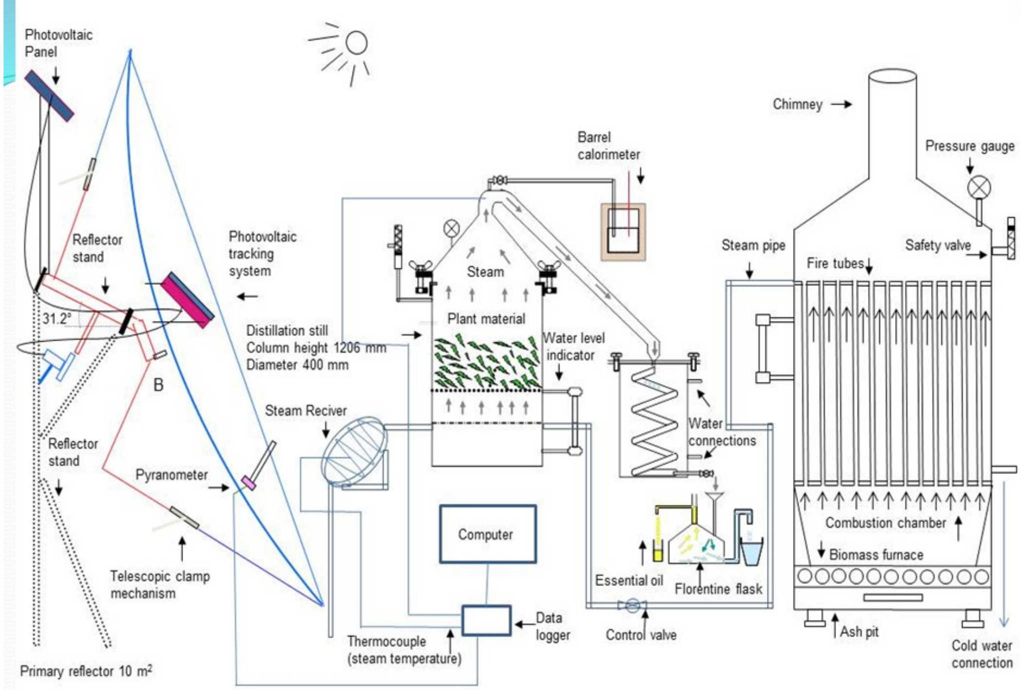
- Same area for intercepting and absorbing of heat -limited to 80 °C
- Suitable for low temperature applications

Concentrating collector

- Converge the beam of incident radiation to smaller area-more flux intensity
- suitable for high temperature
- Tracking problem
- Focus - not fixed

Scheffler concentrator

- Fixed focus
- automatic tracking
- Capable of delivering 300 °C and technical suitable for medium temperature applications (Delaney, 2003)




Solar distillation system
Chimney/stack
Sheffler fixed
focus concentrator
(10 m^2)
PV tracker
Safety valve
Distillation
still
Biomass
Boiler
(vertical
multi-tubelar)
Steam
Reciver
Condenser
Florentine
Boiler
furnace

Different Medicinal Plants for Distillation Experiments

Value Addition for Agriculture Products by Using Solar Distillation System for Rural Development .

Solar Distilled Products

1. Rose water
2. Eye drops
3. Citrus Peel Perfume

Research Publications

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Development of hybrid solar distillation system for essential oil extraction

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Peppermint (Mentha peperita L.)
Pinus (Roxburghii)

ABSTRACT

Use of solar energy for cooking and steam generation is quite common around the world. However, use of solar energy for extraction of essential oils from medicinal and aromatic plants has recently been explored and its effects are still largely unknown. The current study is about essential oil extraction using a newly designed solar distillation system. The devised system consists of a primary reflector (Scheffler concentrator), steam receiver, distillation still, condenser and a florentine flask to enable extraction of essential oils from biomass. An auxiliary biomass system was also coupled with the distillation unit to complement the system during adverse weather conditions or seasonal climatic conditions throughout a typical year. The experimental results show that the concentration of essential oils from fresh Eucalyptus leaves (Camaldulensis) and Peppermint leaves (Mentha peperita L.) were 0.59% w/w and 0.40% w/w, respectively. Essential oil from Pinus (Roxburghii) was extracted using a biomass boiler yielding 0.31% w/w of essential oil. GC-MS analysis confirmed the presence of Eucalyptol (50.9%), Menthol (93.0%) and α-Pinene (70.9%) as the major compounds in Eucalyptus, Peppermint and Pinus, respectively. In summary, solar-based distillation has proven to be a cost effective way of extracting essential oils from medicinal plans and herbs.

1. Introduction

The energy sustainability of any country has a strong correlation with its social and economic development. The rapidly increasing world population has led to adverse effects on ageing infrastructure and increased energy consumption. The limited availability of primary energy sources is posing a severe threat for the continuous energy supply in many developing countries. Many developing countries have been facing severe energy crises, specifically in the last few decades which have adversely affected their domestic, commercial, industrial and agriculture sectors. Furthermore, the environmental consequences associated with energy production including climate change continue to be a challenge for the world. In this regard, the developed countries have already taken initiatives to explore alternative sources of energy for sustainable energy supply in the future. Natural resources such as water for hydroelectric power, solar energy, wind energy, biogas production and biomass resources and biofuel crops [1,2] could potentially meet the demand of developing countries around the world.

Therefore, it is appropriate to increase the reliance on renewable sources of energy in developing countries to cope with environmental challenges caused by the production of energy associated through conventional means. Fortunately, many developed countries have already started working on the exploration, development and direct implementation of renewable energy sources. Out of these renewable energy sources, solar energy is abundantly available in many countries, which can be used for thermal energy and electricity generation [3]. The mean total irradiation falling near the equator is about 200–250 W $m^{-2}day^{-1}$. This amount is about 1500–3000 sunlight hours or 1.9–2.3 MW-hr per year [4]. It is worth mentioning that most of industrial processes like pasteurization, extraction, sterilization, drying, hydrolyzing, distillation, evaporation, washing and polymerization operate in the medium temperature range. The temperature ranges for all these processes lie between 60 and 280 °C [5,6]. One key process commonly used within the same temperature range is distillation, which is used for extracting clean and refined oil from plant materials by evaporating the volatile compounds, which have many useful applications [7,8].

Majority of distillation processes are carried out using conventional energy sources requiring significant amounts of energy. Fortunately, solar-based distillation processes can be used as

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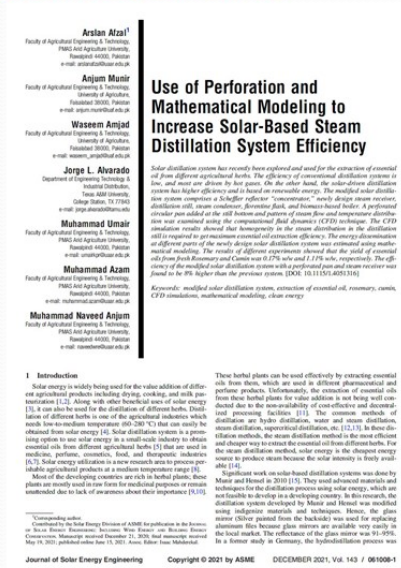

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Use of Perforation and Mathematical Modeling to Increase Solar-Based Steam Distillation System Efficiency

Solar distillation system has recently been explored and used for the extraction of essential oil from different agricultural herbs. The efficiency of conventional distillation systems is low, and most are driven by hot gases. On the other hand, the solar-driven distillation system has higher efficiency and is based on renewable energy. The modified solar distillation system comprises a Scheffler reflector "concentrator," newly design steam receiver, distillation still, steam condenser, florentine flask, and biomass-based boiler. A perforated circular pan added at the still bottom and pattern of steam flow and temperature distribution was examined using the computational fluid dynamics (CFD) technique. The CFD simulation results showed that homogeneity in the steam distribution in the distillation still is required to get maximum essential oil extraction efficiency. The energy dissemination at different parts of the newly design solar distillation system was estimated using mathematical modeling. The results of different experiments showed that the yield of essential oils from fresh Rosemary and Cumin was 0.17% w/w and 1.11% w/w, respectively. The efficiency of the modified solar distillation system with a perforated pan and steam receiver was found to be 8% higher than the previous system. [DOI: 10.1115/1.4051316]

Keywords: modified solar distillation system, extraction of essential oil, rosemary, cumin, CFD simulations, mathematical modeling, clean energy

1 Introduction

Solar energy is widely being used for the value addition of different agricultural products including drying, cooking, and milk pasteurization [1,2]. Along with other beneficial uses of solar energy [3], it can also be used for the distillation of different herbs. Distillation of different herbs is one of the agricultural industries which needs low-to-medium temperature (60–280 °C) that can easily be obtained from solar energy [4]. Solar distillation system is a promising option to use solar energy in a small-scale industry to obtain essential oils from different agricultural herbs [5] that are used in medicine, perfume, cosmetics, food, and therapeutic industries [6,7]. Solar energy utilization is a new research area to process perishable agricultural products at a medium temperature range [8].

Most of the developing countries are rich in herbal plants; these plants are mostly used in raw form for medicinal purposes or remain unattended due to lack of awareness about their importance [9,10]. These herbal plants can be used effectively by extracting essential oils from them, which are used in different pharmaceutical and perfume products. Unfortunately, the extraction of essential oils from these herbal plants for value addition is not being well conducted due to the non-availability of cost-effective and decentralized processing facilities [11]. The common methods of distillation are hydro distillation, water and steam distillation, steam distillation, supercritical distillation, etc. [12,13]. In these distillation methods, the steam distillation method is the most efficient and cheaper way to extract the essential oil from different herbs. For the steam distillation method, solar energy is the cheapest energy source to produce steam because the solar intensity is freely available [14].

Significant work on solar-based distillation systems was done by Munir and Hensel in 2010 [15]. They used advanced materials and techniques for the distillation process using solar energy, which are not feasible to develop in a developing country. In this research, the distillation system developed by Munir and Hensel was modified using indigenize materials and techniques. Hence, the glass mirror (Silver painted from the backside) was used for replacing aluminum files because glass mirrors are available very easily in the local market. The reflectance of the glass mirror was 91–95%. In a former study in Germany, the hydrodistillation process was

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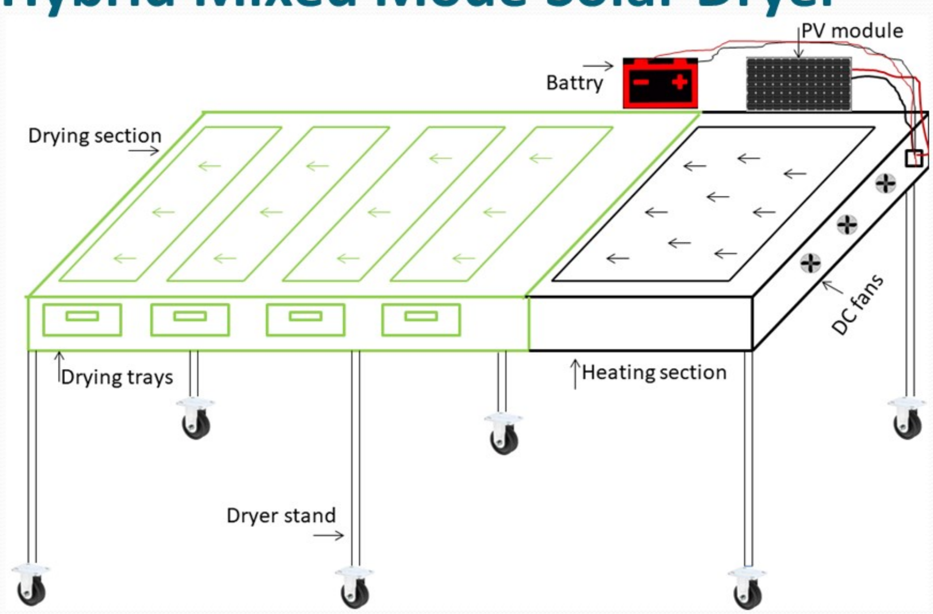
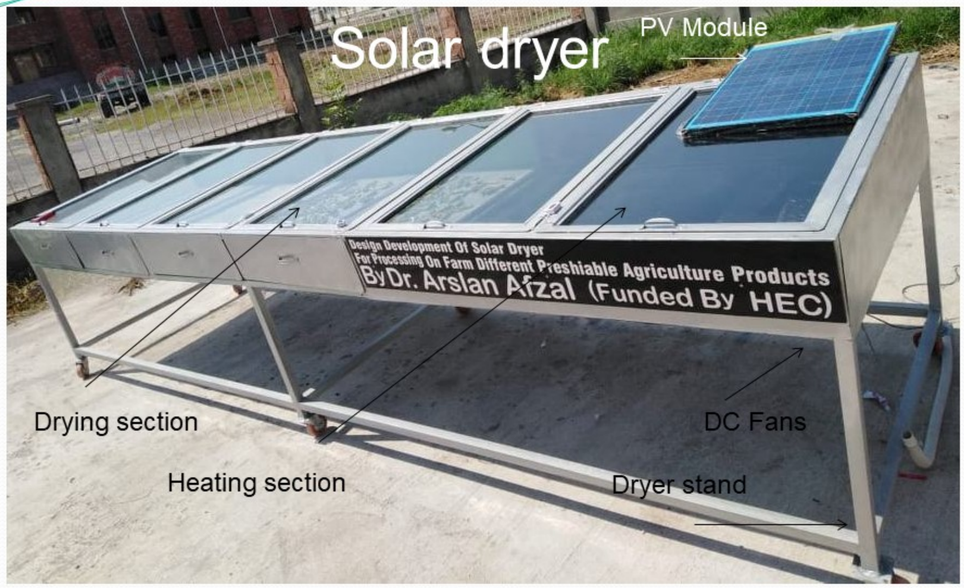
Hybrid Mixed Mode Solar Dryer





Solar Drayed Agricultural products

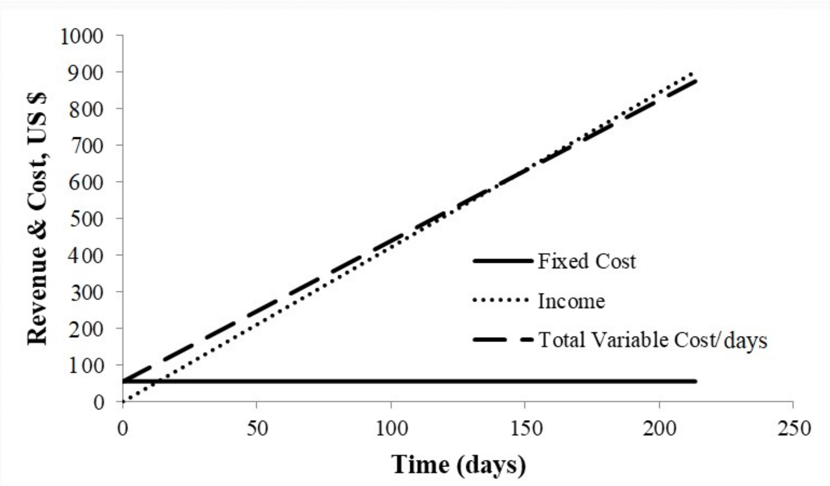
1. Apple (Golden)
2. Chili (Anaheim)
3. Peach (Freestone)

Quality Analysis

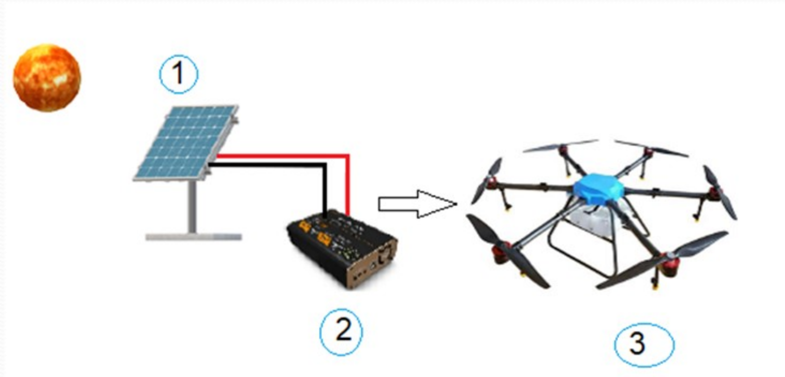
1. Proximate test
2. Total plate count test (TPC)
3. Colour test

The quality analysis results indicate that solar drying does not affect the sample chemical constituents, total bacteria and colour.

Economics analysis



Solar Drone Spryer



1. PV panel
2. Drone charger
3. Solar drone sprayer “Hexacopter”

Research Impact

- **Induction of renewable energy technology**
  - Energy crises in Pakistan
  - Field demonstration for farmers awareness
  - Exploitation of abundently available energy resources

- **Value addition and post harvest technolgy**
  - Huge market of perishable products

- **Skill development**
  - Technical enhancement in design & development
  - Job opportunities
  - Opportunities of higher studies in energy sector

- **Decentralized application**
  - Rural development
  - Reduction in product spoilage
  - Eliminating the role of middle man