Solar Distillation System

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The promotion of small scale agro-based industries by using innovative solar collectors can open new opportunities in rural development. Essential oils extraction from medicinal and aromatic plants is one of the medium temperature agro-based industries. These oils are used for medicinal and pharmaceutical purposes, food and food ingredients, herbal tea, cosmetics, perfumery, aromatherapy, pest, and disease control, dying in textiles, gelling agents, plant growth regulators and paper making. A single ounce of most of the oils has worth thousands of dollars. In the last decade, the oil remedies have gained enormous popularity in industrialized countries particularly in the multi-million-dollar aromatherapy business. Essential oils are extracted from various parts of the plant like leaves, roots, wood, bark, seeds/fruits, flowers, buds, branches, twigs. Out of all extraction methods, the distillation methods have advantages of extracting pure and refined essential oils by evaporating the volatile essence of the plant material. At present, there are large and centralized distillation units mostly located in city areas. Due to their high operating costs, these are, sometimes, unmanageable by farmers or even groups of farmers in most of the developing countries. Further, some essential oils come from extremely delicate flowers and leaves that must be processed soon after harvesting. Thus, for functional, economic and environmental reasons, there is need of a decentralized solar based distillation unit. Due to lack of adequate facilities for the decentralised solar distillation, farmers prefer to dry their product rather to sell it at very low price. Results show that conventional drying methods such as open sun drying and conventional-fuel dryers are not suitable which deteriorate the essential oils components in the medicinal plants. Moreover, the drying process necessitates an enormous amount of thermal and electrical energy. The on-farm solar distillation is a decentralised approach to reduce the post-harvest losses and to prevent spoilage of essential oil components by processing the fresh medicinal plants.

Description of solar distillation system

The solar system was designed as a fixed installation of Scheffler reflector (10 m^2 surface area) and all parts of the reflector stand were fabricated and assembled with respect to the latitude of the site (University of Agriculture, Faisalabad, Pakistan, Latitude: 31.43°). The Scheffler concentrator is a lateral part of a paraboloid and does not require any manual tracking during the whole day once it is set. Further, it provides a fixed focus for all the days of the year which can be best utilized during different distillation experiments. The solar distillation system comprises a primary reflector, secondary reflector, photovoltaic tracking system, distillation still, condenser, Florentine vessels as shown in Figure 1.

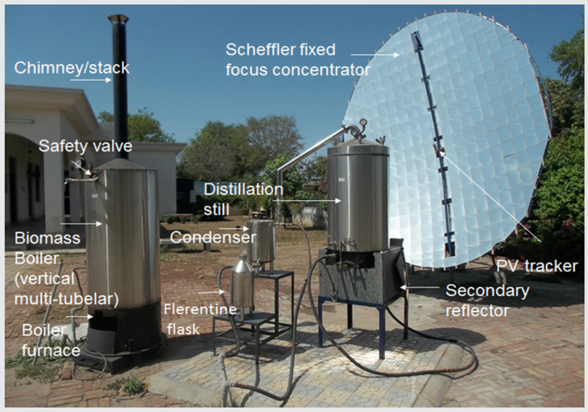

Figure 1. Solar Distillation System installed at University of Agriculture, Faisalabad

The Scheffler reflector is equipped with daily tracking and seasonal tracking system. In daily tracking system, the primary reflector rotates along an axis parallel to the earth axis of rotation with an angular velocity of one revolution per day. This axis of rotation is precisely oriented with respect to zero azimuth angle and latitude of the site (31.43°). In seasonal tracking, telescopic clamp mechanism tracks the sun to cover 47° solar declination (δ). Solar declination varies from -23.5 on December 21 to +23.5 on June 21.

By adjusting the primary reflector at half the solar declination angle with the help of telescopic clamps, it automatically induces the required shape of the parabola with the help of three point triangular pivots. The focus remains fixed and always lies on the line passing through the axis of rotation of the primary reflector. In this way, the reflected beam remains aligned with the fixed focus for all the days of the year.

The fixed secondary reflector further reflects the radiations onto the targeted distillation still bottom. Each morning, the primary reflector has to set back to a starting position in which the secondary reflector is illuminated to start the PV tracking system. The distillation unit is fabricated of a food grade stainless steel material (3 mm thickness) having 1210 mm column height and 400 mm diameter (400 mm diameter is the designed diameter of the receiver for 8 m^2 Scheffler reflector). The still is also provided with safety mountings and fittings like safety valve, pressure gauge, water level indicator etc.

The distillation unit has provision to operate for water and steam distillation. A stainless-steel pipe connects the top end of distillation still to the steel condenser. The condenser is provided with steel coil, a cold-water inlet connection and warm water outlet connection and acts as a counter current flow heat exchanger. In order to evaluate and control the solar distillation system continuously during the experiments, the system is equipped with Pyranometer and thermocouples (K-type and Error < 0.1 K). The intensity of solar radiations is recorded with the help of Pyranometer (SP Lite: response time < 1 S). The Pyranometer is fixed at major axis of the primary reflector with the help of adjustable lever and a 0.020 m long black pipe is mounted on it to record beam radiations. Thermocouple connections are provided to record focal point, water, and steam temperatures during the distillation process. All thermocouples and Pyranometer connections are attached to a computer via data logger.