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Experimental and Computational Analysis of Photovoltaic Powered Cold-pressing of Sunflower Seeds

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Abstract

The mechanical extraction of sunflower seeds is the preferential method for oil production. The oil covers a wide range of applications from food to biofuel, and the residual press cake can be used as animal fodder or for further processing. However, mechanical extraction is difficult to be implemented in rural areas without access to electricity. Cold pressing is a state-of-the-art method to preserve the oil quality. Oil extraction experiments were conducted using a mechanical screw press (IBG Monforts Oekotec, type – CA59G). Key characteristics such as the specific energy input, total electrical energy consumed and oil extraction efficiency were analysed for modelling off-grid applications, powered by photovoltaic modules and batteries. High oleic sunflower seeds of cultivar PR65H22 were obtained from a conventional farm near Würzburg, Germany and used as the feedstock. The experiments comprised variation in rotational screw speeds (18, 28, and 40 rpm), and nozzle diameter (4, 5, 7 and 8 mm). The resulting throughput ranged from 1.2 to 2.9 kg h^{-1}. Minimum and maximum attained torques were 11.0 and 24.9 Nm. Compared to other setups, the smallest nozzle and slowest speed lead to the highest specific energy input (0.79 kWh kg^{-1}), oil recovery efficiency (89.5 %), the maximum yield of raw oil (1.1 kg h^{-1}), and the highest press head temperature (77.3 °C).

Climate data of Nairobi, Kenya, was taken into account for simulating the photovoltaic system. With respect to its performance, the screw press was assumed to be driven at higher angular velocity during sunshine hours and lower ones at night. As a result, an economical optimum was found to maximise the ratio between oil output and investment. The annual simulations also indicated that around 50 % of the whole investment of a solar press system would be related to the photovoltaic components. The system could work between 10 and 14 hours per day, depending on location. The payback periods were estimated to be around 4 to 7 years, strongly depending on local conditions like oil price, transport, installation costs, and climate.

Keywords: Cell, extruder, optimisation, simulation, solar

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