COMPUTATIONAL TOOL TO MODEL AND SIMULATE SOLAR ASSISTED ORGANIC RANKINE CYCLE WITH A THERMAL ENERGY STORAGE

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person expect where the acknowledgment is made in text.

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The above candidate has carried out research for the Masters Dissertation under my supervision.

....	....
Prof. K.K.C.K. Perera	Date

To My Beloved Parents

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ABSTRACT

The Organic Rankine Cycle (ORC) is considered as one of the most promising methods to convert low grade heat into the power. The ORC energy conversion process is much similar to the typical Rankine cycle except for the working fluid. The ORC applicability with low critical point organic fluids enables the operation of the system with low temperature heat sources. This makes low grade solar thermal, waste heat and geothermal suitable heat sources for power generation. Moreover, this applicability of small scale power generation makes it popular for standalone and low quantity heat source applications.

This thesis presents a novel design of solar collector field along with a thermal energy storage to generate electrical power using an ORC. Concentric and non-concentric solar collectors were used to design the cascade collector array considering two collector operating temperatures. Several different collector arrangements of flat plate, evacuated tube, compound parabolic trough and parabolic trough solar collectors were considered. To overcome the intermittent nature of solar irradiation and to extend the number of operational hours, a thermal energy storage system was integrated to the system. Encapsulated phase change materials submerged in a thermal oil bath was considered for this thermal energy storage.

For this investigation, the ORC system was designed according to the maximum load required. However, for the performance evaluation, part load system parameters variation was considered. Two systems were proposed for the evaluation process named system-1 and system-2. The system-1 consists with flat plate and evacuated tube solar collectors with low temperature thermal energy storage and system-2 contains evacuated and parabolic trough solar collectors with medium temperature thermal energy storage. The mathematical model is developed in this research to evaluate the energy flow through system components on an hourly basis. Hourly and seasonal variation of solar energy potential and energy demand were taken and used to simulate the mathematical model using a novel computational tool developed in this study. The system performances were evaluated based on collector area, the capacity of thermal energy storage and ORC thermal efficiency.

Results from the investigation depict the performance of the proposed cascaded solar collector field with different ORC working conditions in a Sri Lankan context. The system performance evaluation was done for five different organic fluids identify optimal working fluids for different system parameters. The evaluated results show the variation of power output, plant factor and system efficiency with different system configurations. The identification of best system performance should be based on both power output and plant factor. However, identification of optimal system depends on both thermodynamic and economic factors. Therefore based on an economic analysis, normalized energy costs can be calculated to identify the best operating conditions along with economic considerations.

Keywords: *Organic Rankine Cycle, PCM storage, Renewable energy, Solar Thermal*

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