National Institute of Technology Rourkela

Synopsis Seminar

Seminar Title	: Thermal Performance Enhancement of Parabolic Trough Solar Collector Using Gaseous Working Fluid and Thermal storage for Efficient Energy Conversion
Speaker	: Sumeet Anand (Rollno : 519me1004)
Supervisor	: Sumit Kumar
Venue	: Seminar Hall (Room Number: ME-001)
Date and Time	: 09 May 2025 (10:00 AM)
Abstract	: The parabolic trough collector (PTC) are the most suitable and mature collectors that justify up to high-temperature applications, per the thermal energy demand. Also, the PTC is a cost-effective technology for producing cleaner electricity, which ultimately suits our energy demand criteria. The PTC experiences highly non-uniformity of temperature distribution in its absorber tube due to imposed of concentrated solar flux which results in the development of significant thermal stress and strain. Hence, this limits the usage of PTC in a greater aspect in the power generation application especially in concentrated solar power plant. Hence, researchers suggested selecting suitable heat transfer fluids (HTFs) or modifying the PTC geometry and its material to overcome the earlier-mentioned limitations. Furthermore, modification of PTC or selection of suitable HTF should be done in such a way that it may improve its performance. In this context, conventional heat transfer fluids, such as water, thermal oils, molten salts, etc., have been limited when the parabolic trough collector works at very high temperatures. Gas may be used as heat transfer fluid when this collector may operate at very high temperatures. Hence, selecting the best suitable gas as heat transfer fluid is essential to improve this collector's thermal performance. However, the heat transfer coefficient of gas is smaller than the conventional heat transfer fluid. Therefore, fins may be used to improve the PTC thermal performance when gas is used as heat transfer fluid. So, the current study has considered different gases along with different shaped longitudinal finned absorber tubes has been investigated. The best suitable gas and optimum fin profile have been chosen based on specific criteria (multi-objective optimization technique or the performance enhancement factor index). Conventional solar power plants need an additional energy storage device to enable smooth operation in off-sunshine hours this requires a large space for storage tank installation and increases the cost associated with its material and maintenance. So, phase change material has been inserted into the receiver tube's annular area in order to address these issues. Thus, the current study focuses on analyzing the parabolic trough collector thermal performance utilizing gaseous heat transfer fluid and phase change material. The current study examined the impact of different phase change materials and gases as heat transfer fluids, on the parabolic trough collector performance. The PTC experiences highly non-uniformity of temperature distribution in its absorber tube due to imposed of concentrated solar flux which results in the development of significant thermal stress and strain. Hence, this limits the usage of PTC in a greater aspect in the power generation application especially in concentrated solar power (CSP) plant due to its high failure. Also, the transient behavior of solar irradiation makes the study highly complex. Therefore, the present study numerically investigates the optical, and fluid-thermal-structural interaction (FTSI), using Monte-Carlo ray tracing (MCRT) method, finite volume method (FVM), and finite element method (FEM). A one-way FTSI approach is considered to study the transient behavior of thermo-fluid and structural performance of the absorber tube. For combining the heat and power technology, the present study proposed a novel layout of the organic Rankine cycle (ORC) system that comprises multiple parabolic trough solar collector systems and a cascaded-based ORC system. The present study aims to increase the thermodynamic performance of this gas-based solar-driven ORC plant in terms of net-work output, thermal, exergy, and combined system efficiency.