

Optimization of organic rankine cycle waste heat recovery for power generation in a cement plant via response surface methodology

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Abstrak

A cement plant that produces 8,300 tons per day releases 265,000 Nm³/h of flue gas at 360°C from its Suspension Preheater (SP) and 400,000 Nm³/h of hot air at 310°C from its air quenching cooler (AQC). It is imperative to recover the waste heat emitted by the plant for power generation, i.e., Waste Heat Recovery Power Generation (WHRPG). This paper aims to optimize waste heat recovery from the cement plant using Response Surface Methodology (RSM), for which an Organic Rankine Cycle (ORC) is applied for electric power generation. The working fluid of an ORC power generation system was selected among candidates of organic working fluids (i.e., isobutane, isopentane, benzene, and toluene) by using the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), a Multi-Criteria Decision Analysis (MCDA) method. The ORC power generation system configuration and the corresponding operating conditions employing the selected working fluid (i.e., pressures and temperatures) are optimized by applying RSM. Based on TOPSIS evaluation and considering factors of health, safety, environment impacts, cost, and power generated, isopentane was selected as the working fluid for the ORC WHRPG, which was configured to consist of a boiler, two expansion turbines, a reheater, and a recuperator. Implementation of RSM attained optimum operating conditions of high pressure turbine, low pressure turbine, and condenser at 11.3 bar-a saturated vapor, 4.3 bar-a and 184°C, and 1.8 bar-a, respectively. Finally, the gross electric power generated of 5.7 MW at 12.5 percent of energy conversion efficiency is generated by the pertinent ORC WHRPG.