Exergy, Exergoeconomic and Exergoenvironomic Analyses of Selected Gas Turbine Power Plants in Nigeria

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abstract

Energy supply trends as well as environmental regulations and climate change issues have made it necessary to closely scrutinize the way energy is utilized. Efficient energy utilization thus requires paying more attention to accurate and advanced thermodynamic analysis of thermal systems. Hence, methods aimed at evaluating the performances of energy systems take into account the Energy, Environment and Economics. Therefore, the first and second law of thermodynamics combined with economics and environmental impact represents a very powerful tool for the systematic study and optimization of energy systems. In this study, a thermodynamic analysis of eleven selected gas turbine power plants in Nigeria was carried out using the first and second laws of thermodynamics, economic and environmental impact concepts. Exergetic, exergo-economic and exergo-environmental analyses were conducted using operating data obtained from the power plants to determine the exergy destruction and exergy efficiency of each major component of the gas turbine in each power plant. The exergy analysis confirmed that the combustion chamber is the most exergy destructive component compared to other cycle components as expected. The percentage exergy destruction in combustion chamber varied between 86.05 and 94.6%. Increasing the gas turbine inlet temperature (GTIT), the exergy destruction of this component can be reduced. Exergo-economic analysis showed that the cost of exergy destruction is high in the combustion chamber and by increasing the GTIT effectively decreases this cost. The exergy costing analysis revealed that the unit cost of electricity produced in the plants ranged from cents 1.88/kWh (₦2.99/kWh) to cents 5.65/kWh (₦8.98/kWh). Exergo-environmental analysis showed that the CO_2 emissions varied between 100.18 to 408.78 kgCO_2/MWh while cost rate of environmental impact varied from 40.18 $/h (N6, 388.62/h) to 276.97 $/h (N44, 038.23/h). The results further showed that CO_2 emissions and cost of environmental impact decrease with increasing GTIT.

Topics: Exergy , Gas turbines , Power stations