ENERGY AND EXERGY ANALYSIS OF A
COMBINED CYCLE POWER PLANT

A Thesis Submitted in Partial Fulfillment of the Requirements for the Master’s of Science
Degree in Mechanical Engineering

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ABSTRACT (ENGLISH)

A block of 460 MW (two gas turbines and one steam turbine) combined cycle power plant has been modeled and simulated based on energy and exergy analysis approaches. The model equations have been solved by the constructed MATLAB computer program. The model accounts for the actual operating parameters within the block components: compressor, combustion chamber, gas turbine, HRSG and steam turbine. The developed program is utilized to investigate the effect of ambient temperature, compressor pressure ratio, as well part load operation, and heat losses in the combustion chamber on the block performance. To validate the present model, the gas turbine performances at different loads are calculated. The results of the present model are compared with the corresponding ones given by the block’s manufacturer. The comparison has shown that the deviations are in the range of 3-5%. Exergy analysis is performed based on the first and second laws of thermodynamics. Its results have shown that the maximum exergy destruction is found to be in the combustion chamber at full and part loads.

The effects of ambient temperature variation on the compressor performance, gas turbine performance and fuel consumption are investigated. The results have shown that the cycle heat rate is found increasing with the net power output of the combined cycle decreases. The steam turbine power output significantly reduces when the ambient temperature is above 25°C has been observed.

The effects of compressor pressure ratio variation on the compressor performance, gas turbine performance and fuel consumption are investigated. The results have shown
that the fuel consumption is started fallen down when the gas turbine is operated at higher compressor pressure ratio has been observed.

The effect of turbine inlet temperature variation on the gas turbine and fuel consumption are investigated. The results have shown that the fuel consumption has shot up rapidly at higher turbine inlet temperature. Therefore it is preferable to increase the compressor pressure ratio proportionally with turbine inlet temperature.

The effects of the percentage of heat losses within the combustion chamber on the fuel consumption, gas turbine cycle efficiency and turbine work net are investigated. The results have shown that the fuel mass flow rate and work net of the gas turbine are increasing as the heat losses increase. On the other hand the thermal efficiency decreases has been observed.

Exergy analysis is performed over wide range of ambient temperature, compressor pressure ratio, turbine inlet temperature and heat losses within combustion chamber variations. The results have shown that the combustion chamber has the largest exergy destruction in the system in all studied cases.

Method of gas turbine power enhancement which is based on air intake cooling to air compressor is discussed. The effect of spray water fogging system on the compressor performance, gas turbine performance and fuel consumption are investigated. The results have shown that the gas turbine power output increased simultaneously with the fuel consumption. In spite of power output increases, the results have shown that heat rate is dropped eventually when the spray water fogging system is employed.