CHAPTER 7

Conclusion and Scope for Future Work

7.1. Conclusions and Key Findings

The present research work studied the performance of an open-cycle MHD power generation system based on thermodynamic evaluation and energy and exergy analysis. The work begins with the performance analysis of an MHD system thermodynamically under constant applied magnetic field strength and gas conductivity. In this work, the performance of an MHD system is evaluated considering the voltage, current, efficiency, and power output within the limits of given working conditions. The effects of nozzle area ratio variation have been studied. The performance study of a thermodynamic model of a coal-fired MHD power generation plant is then carried out using the thermodynamic exergy analysis tool. The analytical solution was obtained considering the energy and exergy evaluation of the MHD components. The MHD system was then evaluated considering the ionization effects on the performance of the major components of the MHD plant and on the overall performance when the MHD system is integrated with a gas turbine plant. The exergy destruction rates and exergetic efficiencies of the different components have been determined and compared to find the most and the least effective component. The results of the analysis were then validated with a known model and found to be nearly similar to the referred model. Lastly, the conventional analysis of a standalone MHD plant under the same ionization effects has been further analyzed by applying the method of splitting the exergy destruction rates.

The major findings are summarized as follows:

- It was observed that such variation in nozzle area ratio affected the inlet temperature of the MHD generator. An increase in area ratio increases the flow Mach number at the generator inlet, gas velocity, maximum power density, and maximum voltage.
- At a constant and subsonic nozzle inlet Mach number, the maximum power density and voltage in the MHD generator are functions of the nozzle area ratio and are independent of the thermal input and currently produced.
- The maximum efficiency was independent of any variation in the nozzle area ratio but depended upon the strength of the applied magnetic field.
- It was found that the occurrence of maximum energy losses and exergy destruction gets shifted to the nozzle when the products of combustion were evaluated in their molecular state and will therefore deviate from the actual results. Moreover, the MHD generator was found to be the second most inefficient component in terms of energy losses and exergy destruction, therefore requiring further improvement. Other components were also found to show similar trends in losses except for the desulphurization unit which was based on the results of energy and exergy analysis.
- The exergetic destructions for the combustor, compressor, seed recovery unit, the sulphur minimizer, and the stack were observed to have lower values corresponding to their energy losses.
- Under the assumed conditions of the combustion product flow streams, the air preheater was found to possess the maximum exergetic efficiency with the least exergy destruction whereas maximum destruction in exergy rate occurs in the nozzle of the MHD plant. Moreover, the MHD system net power output was obtained considering the power supply to drive the air compressor.

- To verify the effects of gas ionization the present analysis evaluated and compared its findings with analysis without ionization and found that ionization of gases was more effective in enhancing the overall performance of the high-temperature energy conversion system.
- The splitting of the exergy destruction into a number of sub-portions was found to be more effective in understanding the actual scenario of the various exergy destructions in components.
- The exergy splitting method provided a way to know the actual improvement possibilities of the different MHD components.
- It also gave informations related to the strengths of interactions among the components and the extent of influence of the components on the performance of the other integrated components.

7.2. Novelty of the Work:

The present work deals with the performance analysis of the MHD power plant. Previous works on MHD are concerned with component analysis and the thermodynamic performance analysis or the exergy analysis that have been conducted but are not sufficiently addressed. Study of MHD plant performance with variation in nozzle area ratio is new of its kind. The exergy analysis of the standalone MHD power plant and its combined form with GT plant have not been undertaken earlier in the true sense so far as the literature is concerned. Moreover, an advanced exergy analysis of the MHD plant is carried out which enable us to properly evaluate the real deficiencies and the related components in the overall MHD plant. Though the advanced method is not new, its application to MHD system is not found in the available literature. So, using this tool for MHD plant analysis is a new way to study the performance of MHD plant.

7.3. Scope for future work:

The above analysis evaluated the MHD power generation system thermodynamically and based on applications of energy and exergy method along with the method of splitting of exergy destructions. The analyses were carried out to estimate the areas of the losses in the MHD system and one of its combined configurations. The analyses incorporated the variation in nozzle area ratio, ionization effects on energy, and exergy analysis and application of the advanced method of exergy analysis to evaluate the performance of the MHD system and its realization possibilities in the near future with further technological improvements in its present components.

The scopes for the future work are stated in the following:

- The method of advanced exergy analysis as applied to the MHD system can be applied to investigate other MHD combined systems as well as advanced exergo-economic and exergo-environmental studies of MHD systems in the near future.
- Studies on the development of new electrode materials, design and use of different configurations of the MHD channel and permanent magnets can be undertaken as a future scope in advancement of MHD.
- Analysis of MHD fluid flow and heat transfer of the ionized gases may be carried out under different conditions for better understanding of such behavior under the influence of MHD.
- Understanding the combustion process using new seed materials, fuel composition will be able to enhance the field of MHD.
- Investigations on the effectiveness of closed-cycle MHD using liquid metals and other working fluids would help in the realization of MHD power.

- Using the present study, future studies on MHD can emphasize more on the ionization aspects for a realistic result.
- Using the advanced exergy results one can be able to successfully undertake the works related to MHD as mentioned in the above first and third scenario.

These are few of the many areas where immediate attention is sought for the possibility of commercialization MHD power as a technologically and economically viable alternate energy conversion system.