INVESTIGATIONS ON SOME FUELS FOR UTILIZATION IN OPEN CYCLE MHD POWER GENERATORS

BY

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TO MY PARENTS

C E R T I F I C A T E

It is certified that the thesis entitled "Investigations on some Fuels for Utilization in Open Cycle MHD Power Generators" being submitted by Ami Chand is worthy of consideration for the award of the degree of Doctor of Philosophy and is a record of the original bonafide research work carried out by him under our guidance and supervision. The results contained in this thesis have not been submitted in part or full to any other University or Institute for award of any degree or diploma.

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Ami Chand

Ami Chand

PREFACE

The electrical conductivity of the working fluid plays a singnificant role in extracting power from an MHD generator.

The electrical conductivity depends on the fuel used and on other parameters like seeding ratio and pressure, in the MHD generator. In this thesis, therefore, investigations on hydrogen, liquefied-petroleum-gas(LPG), watergas and biogas fuels have been carried out in order to assess their suitability for utilization in open cycle MHD power generators. The combustion temperature and the electrical conductivity of these fuels have been analytically evaluated and their dependence on seeding ratio, preheating and/or oxygen enrichment of air, pressure and C/H ratio and calorific value of the fuel have been studied. Experimental measurements of the combustion temperature and the electrical conductivity of seeded (with aqueous K_2CO_3) combustion products of LPG/air, watergas/air and biogas/oxygen systems have been made for various percentages of oxygen enrichment of air, and seeding ratio at atmospheric pressure. Experiments have also been performed for various mixtures of LPG and acetylene (C_2H_2)burnt with oxygen and oxygen enriched air to investigatethe effect of C/H ratio on the electrical conductivity. The experimental values of the temperature and electrical conductivity are found to be in agreement with

the thereotically predicted results. The analytical investigations show that H_2/O_2, LPG/air and water gas/air systems may beutilized in open cycle MHD power generators even up to an operating pressure of 8 atm, while biogas/air-oxygen system can be operated up to 5 atm.

In addition to the achievable electrical conductivity of the seeded combustion products of the fuel, the cost and availability of the fuel also play an important role while selecting a suitable fuel for utilization in MHD power generators. Investigations have, therefore, been made to obtain an optimum combination of fuel from amongst various commercially available gaseous and liquid fuels so that the desir level of electrical conductivity (taken to be 10 mhos-m^{-1} in the present investigations) is achieved at minimum cost. The investigations show that a combination of LPG-C_2H_2 burnt with air and LPG-water gas or LPG - C_2H_2 burnt with preheated air may be suitable fuel combinations for utilization in MHD power generators.

The analytically evaluated values of electrical conductivity have been expressed in the form of a power law in terms of pressure and temperature to facilitate the design analysis of constant Mach number open cycle MHD power generators. Cycle analysis of a portable MHD generator with H_2/O_2 system and steam-bottomed MHD power generators

operated with H_2/O_2 , LPG/air, water gas/air and biogas/air systems have been carried out in order to evaluate values of combustor pressure, duct length and fluid velocity at duct inlet to achieve highest possible efficiency of the plant. Influence of preheating and oxygen enrichment of air, and thermal input on the overall plant efficiency of an optimal designed MHD generator has also been studied. It is found that an overall plant efficiency in the range of 44-48 percent may be obtained by utilizing these fuels in steam-bottomed open cycle MHD power generators. Typically, for an H_2/O_2 system an overall plant efficiency of 47.6 percent can be obtained when the duct length, combustor pressure and duct inlet velocity respectively are kept at 4.75 m, 6 atm and 900 $m\text{-}s^{-1}$.

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