

XVIII. ENERGY CONVERSION RESEARCH*

A. Power Systems with Liquid Generators

Academic and Research Staff

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RESEARCH OBJECTIVES

1. Liquid-Metal Magnetohydrodynamic Power Generation

This phase of our research is concerned with the development of efficient stagnation pressure generators and cycles for use in liquid-metal MHD power systems. The condensing ejector, a two-phase jet pump, is being studied as a possible stagnation pressure generator.

Detailed thermodynamic studies of single-stage and multistage condensing ejector cycles are being carried out and the determination of system weight and MHD generator characteristics is also being undertaken. The stability of the liquid jet and the mixing processes in the condensing ejector are being analyzed. The experimental phase of the condensing-ejector study includes performance measurements for high-efficiency operation and detailed measurements of mixing-section processes.

G. A. Brown

2. Magnetohydrodynamic Induction Generator

The MHD induction machine utilizes the interaction between a traveling magnetic field (such as that produced by a polyphase winding) and a channeled, flowing fluid that may be either a plasma or a liquid metal. Only with a liquid metal is the interaction sufficient for a practical generator.

The theory has reached the point where the operation of the generator is well understood. Effort will be concentrated during the coming year on considering all of the necessary factors in designing a practical induction generator. Chief among these are the best method of minimizing the effect of finite machine length, and including variable channel area, or variable fluid velocity, in the analysis. Also, a study of the induction machine with a mist flow will be finished.

The preliminary study of the experimental induction machine with a low-velocity flow loop has been completed. A new flow loop with increased flow rate and available pressure is now under construction. After testing the existing machine on the new flow loop, an experimental program to study end effects will be started, which will include the design of a new type of coil system and tests on a rotating machine to simulate the linear finite-length machine.

W. D. Jackson, E. S. Pierson

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STATUS OF RESEARCH

1. Liquid-Metal Magnetohydrodynamic Power Generation—Cycle Studies

The simple single-stage cycle consists of a boiler, condensing ejector, MHD generator and radiator. This cycle will be designated BCEGR cycle. The over-all performance analysis for the condensing ejector has been used with the BCEGR cycle to estimate cycle efficiency. For the BCEGR cycle the efficiency is determined by two parameters. One parameter is the ratio of vapor velocity to liquid velocity at the mixing-section inlet. The other parameter is a combination of thermodynamic properties of the working fluid, operating pressure, and MHD generator efficiency. The results of this study will be presented in the next progress report.

G. A. Brown

2. Experimental Condensing Ejector Studies

(i) The condensing ejector test facility has been modified to permit more accurate measurement of the steam conditions at the steam orifice. Dampers have been obtained for the pressure measurement system to reduce the observed pressure oscillations. Additional performance data have been taken under conditions similar to those reported in Quarterly Progress Report No. 79 (pages 149-151). Agreement with other data and theoretical predictions was excellent. The design of a higher contraction ratio mixing section has been started.

(ii) A visual-flow mixing section has been designed and its fabrication started. The mixing section has a constant diameter, is made of high-temperature (400°F) transparent plastic and will contain instrumentation for obtaining data on the axial pressure and temperature histories of the vapor and liquid streams. Wall static taps will be used for pressure measurements. Thermocouple probes will be placed at several axial positions. At a given position, the probes will be displaced in the streams so as to obtain data on the radial temperature profiles. Visual and photographic observations will be made on the jet stability and break-up, drop formation and migration, and so forth. These measurements will be compared with predictions from the available mixing-section analysis. This test section will serve the purpose of obtaining preliminary detailed data for use in the design of later visual-flow test sections and high-efficiency mixing sections.

G. A. Brown

3. Liquid-Metal Magnetohydrodynamic Generators

The design of the new test loop is completed, and the required parts are under construction or on order. It is expected that the flow loop will be in operation and ready for tests with the existing coil structure by the end of the next quarter.

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The design study of practical MHD induction generators is progressing. A better understanding of the difficulties and objectives has been obtained.

The initial theory of the MHD induction machine with a mist flow includes the interaction of single drops with the traveling field and equivalent experiments. A refined single-drop theory will give better correlation with the experiments, and the theory will be extended to include many drops and their mutual interactions.

W. D. Jackson, E. S. Pierson

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B. Alkali-Metal Magnetohydrodynamic Generators

Academic and Research Staff

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RESEARCH OBJECTIVES

The principal objective of this research program is to assess the feasibility of alkali-metal MHD generators for space power generation. Recent experiments and theoretical work have added greatly to our understanding of the electrical behavior of condensing alkali vapors. One of our chief objectives for the coming year is to improve this understanding. Another is to operate a large nonequilibrium MHD generator, with the use of a seeded noble gas as working fluid. The data obtained from it will allow a more realistic assessment of generators that utilize condensable fluid.

J. L. Kerrebrock, M. A. Hoffman

STATUS OF RESEARCH: Alkali-Metal Vapor MHD Generators

During the past quarter, the thesis of Albert Solbes was completed.¹ We are, at present, planning the next series of experiments to be done on the potassium facility. A major portion of our effort has been directed toward the construction and checkout of the large nonequilibrium generator. The facility has been operated at design mass flow (0.4 kg/sec of He) and at 1600°K. Additional external cooling is needed, and the required equipment is being procured. The generator channel has been constructed and is being leak tested, at present. We estimate that the generator will be run for the first time in the early part of December, 1965.

J. L. Kerrebrock

References

1. See J. L. Kerrebrock, M. A. Hoffman, and A. Solbes, "Characteristics of a Pure Alkali-Metal Vapor Plasma," Quarterly Progress Report No. 79, Research Laboratory of Electronics, M. I. T., October 15, 1965, pp. 167-174.

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C. Hall Instabilities and Their Effect on Magnetohydrodynamic Generators

Academic and Research Staff

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Graduate Students

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RESEARCH OBJECTIVES

Our research objective is to obtain further experimental information (using apparatus already available) on the nature of the electrical fluctuations that appear in slightly ionized gases flowing in the presence of a DC magnetic field, and their apparent effect upon the DC (time-average) behavior of the system. Such fluctuations have been observed by several researchers; recently, more detailed information has been obtained in our laboratory. The observed fluctuations are thought to be associated with one or more of the mechanisms for instability which have been identified theoretically for plasmas in a strong Hall field. Our immediate aim is to attempt to prove or disprove this relationship by isolating the various mechanisms through appropriate choice of the working gas, its density and temperature, as well as appropriate choice of the electrical parameters. Since the scope of the project is limited to the use of existing apparatus, several compromises with geometry, and so forth, must be made; nevertheless, we expect that significant new information can be obtained.

J. E. McCune

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