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Magnetohydrodynamic Generators Using Two-Phase Liquid-Metal Flows

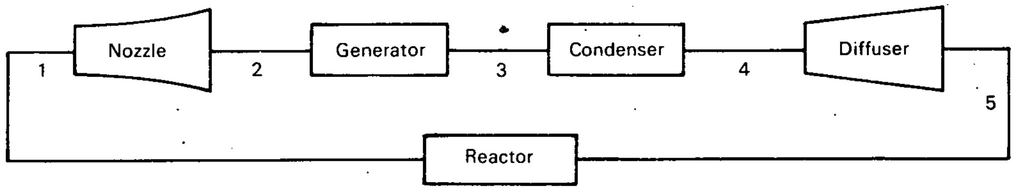

Figure 1. One-component two-phase cycle

The limits of performance of two-phase magnetohydrodynamic (MHD) liquid-metal generators have been explored experimentally over extended parameter ranges, and preliminary data are reported (*1*). Systems incorporating direct-energy-conversion MHD generators, coupled to nuclear reactors and conventional steam bottoming plants, are expected to lead to overall cyclic efficiency of about 50% and so to lower costs of electric power. The generators discussed (*1*) can operate at high efficiencies—about 70%.

In contrast to a Rankine cycle, which employs the vapor phase as the working fluid, liquid-metal MHD cycles must be designed for transfer of the thermal energy of the vapor phase into kinetic energy, or stagnation head, of a fluid of sufficient electrical conductivity to pass through a MHD generator. This constraint in design has given rise to many schemes from which four basic cycles have emerged: (i) the separator cycle, (ii) the condensing-injector cycle, (iii) the multistage cycle, and (iv) the two-phase-generator cycle (Fig. 1).

These four cycles have two underlying philosophies. In the first three, MHD generators operate on kinetic energy deriving from the conversion of thermal energy prior to entry into the generator; a vapor is used to accelerate a liquid, and then the vapor is either separated or condensed; the generation of electric power from the liquid stream is a separate operation. In the two-phase-flow generator cycle studied at Argonne National Laboratory the working fluid is compressible and treated as an expanding gas; the thermal-to-electric conversion proceeds in a single interaction region. The expansion process is similar to that occurring in a plasma generator. The liquid-acceleration cycles are inherently friction-limited and capable of only moderate performance in terms of efficiency, but the two-phase cycle offers the prospect of relatively highly efficient operation; it promises to be highly competitive with not only turbomachinery but also other converters of energy. Either a one- or two-component version of the cycle is possible. Basically the two-phase mixture passes from the heat source through the MHD generator, where the expansion process takes place and the electrical energy is extracted.

The operation of such a two-phase generator is confined to a specific quality range; however, the feasibility of a second type of generator, a film-flow generator, that potentially can accommodate higher-quality mixtures has also been established. The film-flow generator, if placed immediately adjacent to the separator in the separator cycle, could improve overall efficiency by eliminating the transitional losses; or it can combine the functions of separator and generator. The limits of performance of these two generators have been examined experimentally over extended ranges of parameters.

(continued overleaf)

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Reference:

M. Petrick, *SM/74/196* (Argonne National Laboratory, 1968); *I.A.E.A. Symp. Magnetohydrodynamic Electric Power Generation Warsaw July 1968 (SM-107/20)*, pp. 1–24.

Notes:

1. This information may interest researchers in the development of power generation.
2. Inquiries may be directed to:

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Patent status:

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