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MAGNETOHYDRODYNAMICS
New MHD converters: induction machines

A new induction MHD accelerator, disk shaped, with controlled ionization, is presented. Associated with a light and powerful electric generator it could become a MHD aerodyne. Solutions for confining the plasma to the wall are indicated.

Introduction. A previous note [1] described new MHD converters of a particular shape, using a high Hall effect. Some of these devices are currently being tested.

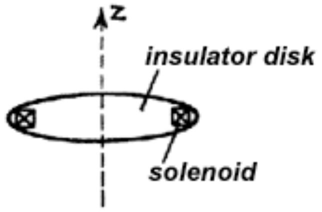

Fig. 1

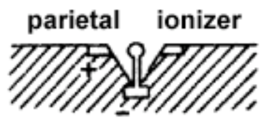

Fig. 2

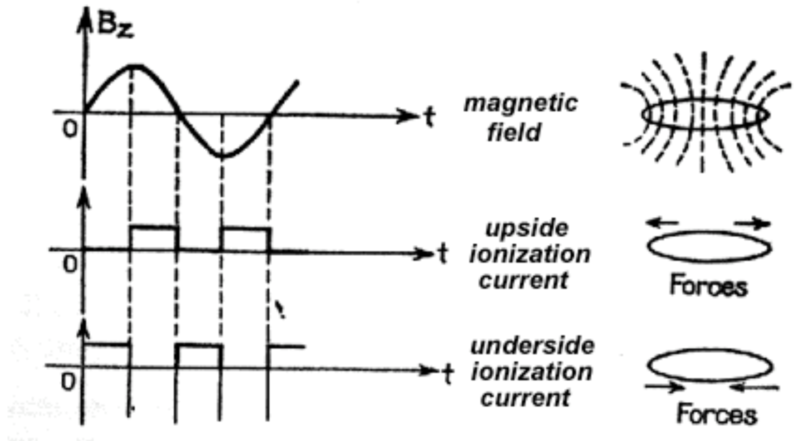

Fig. 3

The MHD accelerator described hereby uses an alternating magnetic field. Let us consider a disk made of an electrically insulating material, its rim being supplied with a solenoid energized by an alternating current (fig. 1). The varying magnetic field creates an induced electrical field and circular eddy currents in the fluid nearby the disk. The Hall effect is considered as negligible. These induced currents combine with the instantaneous value of the magnetic field B, producing radial forces, alternatively centrifugal then centripetal. The system being symmetric, these forces produce only radial excitations, where the momentum integral is equal to zero over one cycle. The induced electric current depends on the peak value and the period P of the B-field. Below some limit of the ratio B/P these induced currents are weak.

Pulsed ionization accelerators. – It is not the same thing if some ionization systems are scattered across the outer walls of the disk (fig.2). Thanks to such a device the electric current can be controlled in any point of the fluid near the wall. The ionizers are powered with a special modulation as represented in fig. 3. The parameters are chosen so the ionization relaxation time is much smaller than the period P of the B-field.

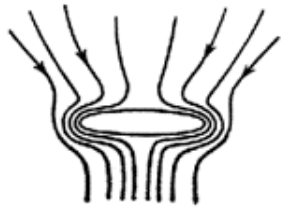

Fig. 4

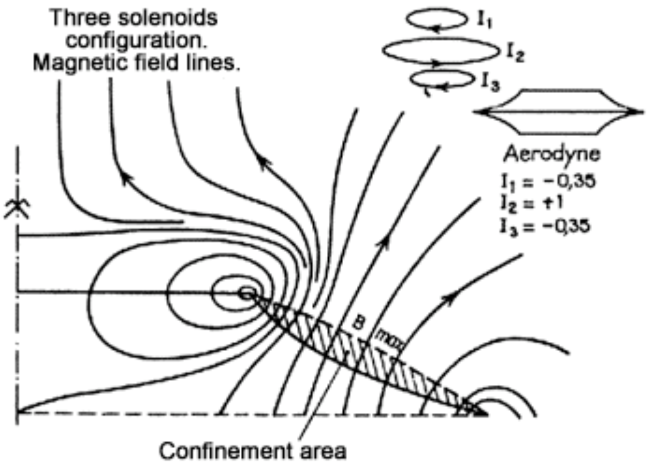

Fig. 5

In this way, when the radial Lorentz forces appear, they are centrifugal on top of the disk and centripetal underside. The ionized air undergoes these forces in a pulsed manner and an induced air flow occurs as illustrated in fig.4.

MHD aerodyne. – If this accelerator owns a self powered energy source, it becomes a MHD aerodyne using electromagnetic induction phenomena and pulsed ionization. In a previous note [1] a MHD engine was described. A "two-stroke engine" where fusion reactions would ignite at the end of the MHD compression stage. The plasma would then act as a Hall generator while the plasma is in an expansion phase.

In a recent paper by Ralph Moir [2] an alternating MHD engine, quite different and apparently more simple, has been proposed. The central element is a toroidal chamber like a tokamak. Moir estimates the Lawson criterion could be reached in such a device through a theta-pinch MHD compression. The fusion plasma expansion compresses the magnetic field lines and there is a direct energy conversion by induction. The advantage of such a dual formula, where both the aerodyne and its engine work thanks to electromagnetic induction, is that the very high currents do not need to flow through electrodes anymore.

Plasma confinement to the wall. – The inductive solenoid in this discoidal accelerator generates a magnetic field which is maximal on the wall. So the magnetic pressure tends to blow the electrical discharge away from the wall. In order to locally control the MHD interaction, the shape of the aerodyne and its magnetizing system must be modified to accomodate a maximum field not on the wall, but in its vicinity. This can be done thanks to a geometry involving several solenoids, as shown in fig. 5. The calculation shows the magnetic strength reaches its maximal value along an approximately conical surface. The wall has to be modeled orthogonal to the magnetic field lines, in order for the Lorentz forces to be tangent to it. The idea of the MHD aerodyne comes from Jean-Pierre Petit, and the confinement geometry with several solenoids from Maurice Viton.

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[1] J.P. Petit, "New MHD converters". Comptes rendus de l'Académie des Sciences 281 (11): 157–160. Paris: French Academy of Sciences, September 15, 1975.

[2] R. Moir, "Direct Conversion of Energy from Fusion", UCRL 76096, report Lawrence Livermore National Laboratory, CA, USA.