Mhd aerodynes, with wall confined plasma, electrothermal instability annihilated and stable spiral current pattern.

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MHD propulsion has been extensively studied since the fifties. To shift from propulsion to an MHD Aerodyne, one only needs to accelerate the air externally, along its outer skin, using Lorentz forces. We present a set of successful experiments, obtained on a disk-shaped model, placed in low density air. We successfully dealt with various problems: wall confinement of two-temperature plasma obtained by inversion of the magnetic pressure gradient, annihilation of the Velikhov electrothermal instability by magnetic confinement of the streamers, establishment of a stable spiral distribution of the current, obtained by an original method. Another direction of research is devoted to the study of an MHD-controlled inlet which, coupled with a turbofan engine and implying an MHD-bypass system, would extend the flight domain to hypersonic conditions.

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1.Introduction

During the sixties it was shown that if the electrical conductivity of the gas was large enough (3,000 S/m), Lorentz forces \( J \times B \) (\( B = 2 \) teslas) could deeply modify the gas parameters of a supersonic flow (\( M = 1.4 \)) in a Faraday MHD converter [1]. In a constant cross section channel, when slowing down the gas (short duration argon flow, \( T = 10,000^\circ K \), \( p = 1 \) bar, \( V = 2750 \) m/s, delivered by a shock driven wind tunnel) when slowing down, the deceleration was strong enough to create a front shock wave, without any obstacle. Accelerating the gas, velocity gain of 4,000 m/s were obtained along a 10 cm MHD channel [1]. In supersonic flows, shock waves occur when the local slowing down is strong enough to produce self crossing of Mach lines. See figure 1.

![Figure 1](image-url)

**Figure 1.** Two dimensional flow around a flat wing. Mach lines computed from Navier-Stockes equations. A : self crossing phenomenon. B : With shock waves system [2,3].

It was shown, based on 2d-numerical calculation and hydraulic simulation that those shock waves could be eliminated if a suitable Lorentz force was applied around the model [2-5].
The gas must be accelerated around the leading edge and the bottom, and slowed down between the two to prevent the expansion fan. By the way, this introduced the concept of MHD bypass. In the eighties it was planned to use a shock tube as a supersonic, high electrical conductivity gas flow generator, to operate this key-experiment. But, due to the connexion to UFO phenomenon (supersonic silent flight, as reported by witnesses) this was no longer possible in institutional structures. Years after, the Lambda Laboratory was created (2007) with private funding. The use of a shock tube was too complex and expansive, so that the team shifted to experiments in low pressure hypersonic wind tunnel, providing natural high electrical conductivity. Then disk shaped MHD aerodynes, as described in references [6] and [7] are more suitable, due to the high Hall parameter conditions. This arises specific difficulties, such as the tendency of the discharge to be blown away, due to the magnetic field gradient. This was rapidly solved, by wall confinement through inversion of magnetic gradient.

As we used a two temperature plasma (Te > Tg) in unstable conditions, with respect to electrothermal (Velikhov) instability, we operated successfully an instability cancellation method by streamers confinement by magnetic pressure gradient control [8-10].
Figure 4. Annihilation of the electrothermal instability [10].

The MHD aerodyne concept is a set of many formulae, described in reference [11], including induction systems with pulsed wall controlled ionization by microwaves or micro wall ionizers. In figure 5, the schema of the MHD aerodyne working with spiral currents.

Figure 5. MHD aerodyne with spiral current

2. Recent work.

The team works on this system, which implies spiral current pattern. If one tries to obtain such pattern with all couples of electrodes simultaneously fed, the result is poor (figure 6 left). Using a sequential feeding we got good looking spiral pattern (figure 6 right), the criterium being the following: in order to control the flow, the commutation period must be small with respect to the transit time of the gas around the disk shaped machine.

Figure 6. Spiral current pattern
References


