MHD Propulsion

William Sutcliffe and Tom Neiser, 19th June 2009

Abstract(by Tom Neiser):

This paper investigates the construction of small scale Magnetohydrodynamic(MHD) propulsion systems and the optimisation of engine performance. The experimental thrust of $F = 0.04 \pm 0.01N$ was found to be dependent on the strength of the magnetic field, the salt water resistivity and the engine dimensions. Measurements with a Hall probe were made to determine the magnetic field strength distribution of the component magnets. By combining this data with the factors affecting thrust this paper evaluates the optimum engine width as $16.0 \pm 0.5mm$. Large scale commercial and military MHD propulsion, however, cannot compete with more efficient conventional propulsion systems.

1. INTRODUCTION Tom Neiser

In the Hollywood blockbuster "*The Hunt for Red October*"[1] a Russian submarine employs a silent MHD propulsion system, making it impossible to be detected. But what is MHD, how does it work and why don't we see it in our everyday life? The field of MagnetoHydroDynamics(MHD) studies the motion of electrically conducting fluids in the presence of a magnetic field. Any conducting fluid such as salt water has free ions that can carry a current. A magnetic field acting perpendicular to the direction of current flow accelerates moving ions at right angles to the directions of both current flow and the magnetic field due to the Lorentz force. According to momentum conservation this creates a thrust which can be harnessed for the propulsion of a vessel, which is explained in Section 2 in greater detail. This project endeavours to design two small vessels propelled by MHD engines. Subsequent measurements of thrust, current flow and the magnetic field strength distribution enable optimum engine dimensions to be determined. Following these investigations the report evaluates the possibility of large scale application of MHD propulsion, which was pioneered by the design[2] of the *Yamato 1*.

2. BACKGROUND THEORY William Sutcliffe

The flow of current, I, through an electrically conducting fluid such as plasma or salt water in the presence of a magnetic field, B, will result in a Lorentz force, F. This will act on the charges carrying the current.

$$\boldsymbol{F} = I\boldsymbol{L}\times\boldsymbol{B} \qquad (1)$$

Where $\boldsymbol{L}$ is the length along which the current acts and is in the direction of conventional current flow. The Lorentz force will be perpendicular to both the magnetic field and the current as $\boldsymbol{L}\times\boldsymbol{B}$ is a vector cross product. This is shown on the rectangular channel in Fig. 1.

[1] Paramount Pictures(1989); "The Hunt for Red October", based on the eponymous novel by Tom Clancy (Naval Institute Press, Annapolis, 1984)

[2] Designed by the Mitsubishi Corp., 1991; see Bibliography