Experimental investigation of transition to turbulence in a Magnetic Obstacle

- BIFD2011 -

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ABSTRACT

We present an experimental study about the structure of the liquid metal flows under the influence of confined non-homogeneous magnetic fields, so called magnetic obstacle [1]. We study the sequences of vortex generation and the structure of bifurcations in the flow of eutectic alloy GaInSn. A $1200\mathrm{mm}$ long channel with a rectangular $100\mathrm{mm} \times 25\mathrm{mm}$ cross section made of Plexiglas is used in this experiment. The channel is filled up with $10\mathrm{mm}$ GaInSn and has one Hartmann wall, one free surface and two side walls. A permanent $20\mathrm{mm} \times 30\mathrm{mm} \times \mathrm{amm}$ magnet will be installed on a moving rail beneath the channel and will have the Hartmann number about $\mathrm{Ha} = 110$. The experimental set up enables us to move the magnet with constant velocities varying from $5\mathrm{mm.s}^{-1}$ to $80\mathrm{mm.s}^{-1}$, i.e. $\mathrm{Re} = 125 - 2000$. We are also able to change the magnet length (a). A camera which moves with the magnet will record the vortex generation sequences and a strain gauge will record the amount of Lorentz force exerted on the magnet.The streamlines has been illuminated using gas bubbles generated due to the reaction of the acid HCl and GaInSn oxide on the free surface.The flow is shown to undergo really complicated phenomena. As the velocity and hence the Re Number and interaction parameter changed, we observed different behaviours inside the magnetic field region and in downstream. These includes formation of bifurcations or their suppression, vortex shedding behind the magnet, symmetry breakdown, dupplication of vortices and also a behaviour that looks like intermittency. The vast number of phenomana related to instability that are visible in the fluid flow past a magnetic obstacle make it worth investigating in order to achieve a better understanding of magnetic obstacle or even turbulence. Here we will reperesnts the results of our experiments and compare them with the theoretical predictions of the reference literatures.

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