MAGNETIC FIELD ADVECTION IN LIQUID SODIUM FLOW IN TOROIDAL CHANNEL

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The interaction of a liquid sodium flow in a bronze toroidal channel with an alternating magnetic field is considered. The magnetic field traveling along the channel is generated by the external system of coils. The process of magnetic field transfer by the flow of liquid metal is investigated experimentally by measuring the induced phase shifts with respect to the external field. The phase shift obtained from the analysis of the experimental signals is evaluated based on the wavelet analysis.

The results of calculations have indicated that with increasing frequency of the magnetic field the skin-effect becomes more pronounced even near the resulting inhomogeneous magnetic field. Therefore, at high frequencies only the near-wall part of the sodium flow will predominantly participate in the field transport. The higher is the frequency of the alternating field, the thinner is the near-wall sodium layer that participates in field transport. Hence, by changing the magnetic field frequency, one can determine the intensity of field transport by various sodium layers, namely, the transport of the field from the thin near-wall layer (at high frequency) to the layer almost coinciding with the channel cross-section (at low frequency). This has led us to conclude that the proposed method can be used to recover the velocity profile of liquid metal in the channel. Numerical calculations show that magnetic field distribution throughout the cross-section of the channel filled with liquid metal is essentially inhomogeneous. One-dimensional approximation yields only preliminary estimates of profile recovery. For more accurate recovery of velocity data, the 3D magnetic field distribution should be used.

Experimental studies provided evidence that the velocity profile reconstruction is possible. The magnetic field excited in liquid sodium was significantly weakened because of the external bronze shell, nevertheless the sensitivity of the 24-charge system for voltage measurements was sufficient for determining the phase shift due to advection by sodium. The phase shift calculation based on the wavelet analysis is less sensitive to a noise and can be easily adopted for analysis of signal with a time dependent frequency. Three braking regimes produced three different values of the phase shift which means sensitivity to the flow intensity. In addition, different frequencies of the external magnetic field were considered. It helps to estimate the flow intensity at different depth. The obtained results will be used in the next stage of our investigation devoted to the development of the procedure required for recovering information about the velocity profile.