Nomenclature

\( A \)  Cross-sectional area of the pipe (\( m^2 \))

\( A_d \)  Projected area of the bubble (\( m^2 \))

\( a_i \)  Interfacial area per unit volume (\( m^2/m^3 \))

\( B \)  Magnetic field intensity (T)

\( C \)  Constant (= RT)

\( C_{h_k} \)  Distribution parameter of enthalpy flux for k-phase (dimensionless)

\( C_{v_k} \)  Distribution parameter of the momentum flux for k-phase (dimensionless)

\( C_{pr} \)  Specific heat of vapour/gas (\( j/kg \) K)

\( C_{pl} \)  Specific heat of liquid metal (\( j/kg \) K)

\( C_D \)  Drag coefficient (dimensionless)

\( C_{km} \)  Virtual mass coefficient (dimensionless)

\( C_0 \)  Distribution parameter of void fraction (dimensionless)

\( D_b \)  Bubble diameter at the mixer exit (m)

\( D_h \)  Orifice hole diameter (m)

\( D \)  Diameter of the pipe (m)

\( d \)  Individual zone length at measurement location (m)

\( f_{lo} \)  Friction coefficient for liquid metal only

\( f_R \)  Friction factor

\( F_r \)  Froude number (dimensionless)

\( F_D \)  Drag force (N)

\( F_{km} \)  Virtual mass force (N)

\( h \)  Electrode spacing (m)

\( H \)  Enthalpy (\( j/kg \))

\( H_{ki} \)  Enthalpy of k-phase at interface (\( j/kg \))
$g$  
Acceleration due to gravity (m/s$^2$)

$G_i$  
Mass flux (kg/sm$^2$)

$I$  
Attenuated gamma photon counts (s$^{-1}$)

$J_v$  
Superficial vapour/gas velocity (m/s)

$J$  
Current density in y-direction (A/m$^2$)

$J_z$  
Current density in z-direction (A/m$^2$)

$k$  
Load factor (dimensionless)

$I$  
Electrode length (m)

$L_e$  
Entrance length (m)

$L_b$  
Bubble length (m)

$L_c$  
Magnetic field decay length (m)

$L_s$  
Length scale of interface (1/$a_s$)

$m$  
Mass flow rates (kg/s)

$M_{ak}$  
Generalised interfacial drag (N/m$^3$)

$\langle M_{i}^{d}\rangle$  
Total interfacial shear force (N)

$N_{\text{Elec}}$  
Electrical power in MHD generator (kW$_e$)

$N_{\text{Rev}}$  
Reynolds number of the vapour at the mixer orifice (dimensionless)

$p_k$  
Pressure of k-phase (bar)

$P$  
Pressure (bar)

$q_i$  
Conduction heat flux of k-phase (k j/kg)

$q_i'$  
Turbulent heat flux of k-phase (k j/kg)

$q_{i,k}$  
Interfacial heat flux into k-phase (k j/kg)

$r$  
Electrical resistance (Ω)

$r_s$  
Bubble radius (m)

$r_d$  
Drag radius (m)

$r_s$  
Surface equivalent radius (m)

$r_{sem}$  
Sauter mean radius (m)
\( r_v \) Volume equivalent radius (m)
\( R \) Gas constant (J/kg K)
\( Re_l \) Liquid Reynolds number
\( Re_v \) Vapour Reynolds number
\( S \) Slip (dimensionless)
\( S_v \) Sievert (J/kg)
\( t \) Time (t)
\( T \) Temperature (K)
\( u \) Average velocity of the liquid metal in the MHD Channel (m/s)
\( u_i \) Velocity of the liquid metal in the riser (m/s)
\( u_v \) Velocity of the vapour/gas in the riser (m/s)
\( v_r \) Local relative velocity between phases (m/s)
\( \bar{v}_r \) Relative velocity between mean phases (m/s)
\( \langle v_r \rangle \) Area average of local relative velocity (m/s)
\( V \) Voltage (V)
\( V_b \) Volume of the bubble (m\(^3\))
\( w \) Width of the electrode (m)
\( W_e \) Weber number (dimensionless)
\( X \) Quality (dimensionless)
\( x \) Distance along the direction perpendicular to the electrode surface (m)
\( y \) Distance along the direction parallel to the electrode surface (m)
\( z \) Distance along flow from the mixer exit (m)

**Greek symbols:**

\( \alpha \) Area average void fraction
\( \alpha_s \) Void fraction in liquid slug
\( \alpha_w \) Void fraction at wall of the pipe
\[ \beta \] Line averaged void fraction
\[ \varepsilon \] Total error
\[ \lambda \] Parameter for a special convective derivative
\[ \phi \] Electrical potential
\[ \xi_h \] Heated perimeter
\[ \xi \] z/D
\[ \tau_i \] Mean interfacial shear stress
\[ \bar{\tau}_k \] Average viscous stress for k-phase
\[ \tau_{sw} \] Wall shear stress for vapour/gas phase
\[ \tau_w \] Total wall stress
\[ \rho \] Density (kg/m\(^3\))
\[ \Gamma_k \] Mass source for k-phase
\[ \Sigma_i \] Surface tension of liquid metal
\[ \sigma_i \] Electrical conductivity
\[ \Delta P_{\text{MHD}} \] Pressure drop due to MHD forces
\[ \phi_{lo} \] Two-phase multiplication factor for liquid metal only
\[ \Phi_i \] Energy dissipation

**Subscripts and symbols:**

- \( cs \): Cross-sectional effect accounted
- \( D \): Drag
- \( fr \): Friction
- \( frlo \): Friction with liquid only
- \( g \): Gas
- \( i \): \( i^{th} \) chord, interface
- \( in \): Internal resistance
- \( j \): \( j^{th} \) zone
\( k \)  
\( l \)  
\( l. \)  
\( t \)  
\( v \)  
\( VM \)  
\( w \)  
\( < > \)  
\( \{\{ \}{}\} \)  
\( D_x \) \( \frac{\partial}{\partial t} \)  
\( 0 \)  
\( 1 \)  
\( 2 \)  
\( 3 \)  
\( 4 \)  
\( 5 \)  
\( 6 \)  

k-phase (\( k = \text{liquid or vapour phase} \))  
Liquid metal  
External resistance  
Two-phase  
Vapour  
Virtual mass  
Wall  
Area average  
Weighted mean area average  
Convective derivative of k-phase  
centre of the MHD generator  
mixer  
separator inlet  
separator outlet  
transitional piece inlet  
generator entrance  
generator exit