附錄 A

參考圖 A-1 至 A-6，吾人推導之離散化後統御方程式書寫如下:

A.1 方程式之離散化

孔質區動量方程式

$$A_j \delta v_{j-1} + B_j \delta v_j + C_j \delta v_{j+1} = D_j \qquad \text{<A.1>}$$

其中

$$\begin{aligned}
& j = 1 \\
& B_1 = \frac{2}{h_1} + h_1 \left(E_1 + 2E_2 v_1 \right) \\
& \hat{C}_1 = \frac{-2}{h_1} = A_1 + C_1 \\
& D_1 = \frac{2}{h_1} v_2 - \frac{2}{h_1} v_1 + 2m_{eff} \cdot s + \left[E_3 - \left(E_1 + E_2 v_1 \right) v_1 \right] h_1
\end{aligned} \qquad \text{<A.2>}$$

$$\begin{aligned}
& j = J-1 \\
& A_{J-1} = \frac{-1}{h_{J-2}} \\
& B_{J-1} = \frac{1}{h_{J-2}} + \frac{1}{h_{J-1}} + \frac{h_{J-2} + h_{J-1}}{2} \left(E_1 + 2E_2 v_{J-1} \right) \\
& C_{j-1} = 0 \\
& D_{J-1} = -\left(\frac{1}{h_{J-2}} + \frac{1}{h_{J-1}} \right) v_{J-1} + \frac{1}{h_{J-2}} v_{J-2} + \left[E_3 - \left(E_1 + E_2 v_{J-1} \right) v_{J-1} \right] \frac{h_{J-1} + h_{j-2}}{2}
\end{aligned} \qquad \text{<A.3>}$$

管壁能量方程式

$$A_j \overline{\theta}_{j-1}^{n+1} + B_j \overline{\theta}_j^{n+1} + C_j \overline{\theta}_{j+1}^{n+1} = D \qquad \text{<A.4>}$$

$3 \le j \le J-2$

$$A_j = 1 = C_j, B_j = -\left[2 + \frac{(\Delta y)^2}{\boldsymbol{a}'\Delta \boldsymbol{t}}\right], D_j = \frac{(\Delta y)^2}{\boldsymbol{a}'\Delta \boldsymbol{t}} \bar{\boldsymbol{q}}_j^n$$ <A.5>

在內部介面 $y = 1$

$j = 1$

$$\bar{\boldsymbol{q}}_1 = \boldsymbol{q}_{w1}$$ <A.6>

$j = 2$

$\bar{\boldsymbol{q}}_1 = \boldsymbol{q}_{w1}$

$$B_2 = -\left[2 + \frac{(\Delta y)^2}{\boldsymbol{a}_W{}'\Delta \boldsymbol{t}}\right]$$ **其中** $D_2 - A_2\boldsymbol{q}_{w1} = D_2^*$ <A.7>

$C_2 = 1$

$$D_2^* = -\frac{(\Delta y)^2}{\boldsymbol{a}'_W\Delta \boldsymbol{t}} \bar{\boldsymbol{q}}_2^n - 1 \cdot \boldsymbol{q}_{w1}$$

在外部邊界 $y = 1 + \frac{H_w}{H}$ <A.8>

$j = J-1$

$$A_{J-1} = 1, B_{J-1} = -\left[2 + \frac{(\Delta y)^2}{\boldsymbol{a}_W{}'\Delta \boldsymbol{t}}\right], C_{J-1} = 0, D_{J-1} = \frac{(\Delta y)^2}{\boldsymbol{a}'_W\Delta \boldsymbol{t}} \bar{\boldsymbol{q}}_{J-1}^n$$ <A.9>

流體相能量方程式

$$A_{i,j}\langle \boldsymbol{q}\rangle'_{f(i,j-1)} + B_{i,j}\langle \boldsymbol{q}\rangle'_{f(i,j)} + C_{i,j}\langle \boldsymbol{q}\rangle'_{f(i,j+1)} = D_{i,j}$$ <A.9>

其中

$i = 2,3,\dots, I-1$

$j = 2,3,\dots, J-1$

$$A_{i,j} = \frac{k_{fej-\frac{1}{2}}}{h_{j-1}}, \quad C_{i,j} = \frac{k_{fej+\frac{1}{2}}}{h_j}$$ <A.10>

$$(A) = k_{fex}\frac{\langle \boldsymbol{q}\rangle_{f(i-1,j)} - 2\langle \boldsymbol{q}\rangle_{f(i,j)} + \langle \boldsymbol{q}\rangle_{f(i+1,j)}}{(\Delta x)^2}$$

$$B_{i,j}=-\left(A_{i,j}+C_{i,j}\right)-\Pr_f \operatorname{Re}_h \langle u\rangle_{i,j}\frac{h_{j-1}+h_j}{2\Delta x}-\frac{e}{\Delta t}\frac{h_{j-1}+h_j}{2}$$

$$D_{i,j}=\left[-Bik_s\left(\langle q\rangle_{s(i,j)}-\langle q\rangle_{f(i,j)}\right)-\frac{\Pr_f \operatorname{Re}_h}{\Delta x}\langle u\rangle_{i,j}\langle q\rangle'_{f(i-1,j)}-\frac{e}{\Delta t}-k_{f(i,j)}-(A)\right]\frac{h_{j-1}+h_j}{2}$$

<A.11>

$i=2,3,\ldots,I-1$

$j=1$

$$B_{i,j}\langle q\rangle'_{f(i,1)}+\left(A_{i,1}+C_{i,1}\right)\langle q\rangle'_{f(i,2)}=D_{i,j}$$ **<A.12>**

$$\hat{C}_{i,1}=2\frac{k_{fe\frac{3}{2}}}{h_1}$$

$$B_{i,1}=-\frac{2}{h_1}k_{fe,\frac{3}{2}}-\Pr_f \operatorname{Re}_h \langle u\rangle_{i,1}\frac{h_1}{\Delta x}-\frac{eh_1}{\Delta t}$$

$$D_{i,1}=h_1\left[-Bik_s\langle q\rangle_{s(i,1)}-\frac{\Pr_f \operatorname{Re}_h}{\Delta x}\langle u\rangle_{(i,1)}\langle q\rangle_{f(i,1)}-\frac{e}{\Delta t}\langle q\rangle_{f(i,1)}-(A)\right]$$

<A.13>

固相能量方程式

離散化與液相類似，所以不加詳述。