
Section 2.3: Viscous Stresses

Figure 2.3b on page 15 (stress components got interchanged):

![Viscous Stresses Diagram](image)

Section 3.1.5: Central and Upwind Schemes

Text on page 42, initial paragraph:

... In this context, it is convenient to differentiate between the discretization of the convective and the viscous fluxes ($\vec{F}_c$ and $\vec{F}_v$ in Eq. (2.19), respectively). ...

Chapter 4: Structured Finite-Volume Schemes

Equation (4.64) on page 96:

$$M_R = \begin{cases} 0 & \text{if } M_R \geq +1 \\ -\frac{1}{4}(M_R - 1)^2 & \text{if } |M_R| < 1 \\ M_R & \text{if } M_R \leq -1 \end{cases}$$
Chapter 5: Unstructured Finite-Volume Schemes

Equation (5.9) on page 128:
\[ \vec{r}_c = \frac{\Omega_{123} \vec{r}_{c,123} + \Omega_{134} \vec{r}_{c,134}}{\Omega_{123} + \Omega_{134}}. \]

Equation (5.23) and text following on page 135:
\[ \bar{n}_{01} \Delta S_{01} = \bar{n}_L \Delta S_L + \bar{n}_R \Delta S_R, \]
and the total face area is given by:
\[ \Delta S_{01} = ||\bar{n}_L \Delta S_L + \bar{n}_R \Delta S_R||_2. \]

Equation (5.62) on page 153:
\[ \alpha_{ij,1} = \frac{\Delta x_{ij}}{r_{11}^2}, \]
\[ \alpha_{ij,2} = \frac{1}{r_{22}^2} \left( \Delta y_{ij} - \frac{r_{12}}{r_{11}^2} \Delta x_{ij} \right), \]
\[ \alpha_{ij,3} = \frac{1}{r_{33}^2} \left( \Delta z_{ij} - \frac{r_{23}}{r_{22}^2} \Delta y_{ij} + \beta \Delta x_{ij} \right), \]

Equation (5.74) on page 162:
\[ \left( \frac{\partial U}{\partial \ell} \right)_{IJ} \approx U_J - U_I \ell_{IJ}. \]

Chapter 6: Temporal Discretization

Reference [20] related to Eq. (6.22) on page 176:

Equations (6.76), (6.77) and the related text on page 199:
\[ \vec{R}_i^{(p+1)} \approx \vec{R}_i^{(p)} + \hat{J}_i \Delta \vec{W}^{(p)} \]
with \( \Delta \vec{W}^{(p)} = \vec{W}^{(p+1)} - \vec{W}^{(p)} \) and \( \hat{J} = \partial \vec{R} / \partial \vec{W} \) being the Jacobian matrix. Inserted into Eq. (6.75) while formulated as an iterative procedure, we obtain for the solution at stage \( k \) the expression
\[ \left[ \frac{(\Omega M)_I}{\Delta t} + a_{kk} \hat{J}_I \right] \Delta \vec{W}^{(p)} = \frac{(\Omega M)_I}{\Delta t} \left( \vec{W}_I^{(n)} - \vec{W}_I^{(p)} \right) - \sum_{l=1}^{k-1} a_{kl} \vec{R}_l^{(l)} - a_{kk} \vec{R}_k^{(p)}. \]
This is formally equivalent to Eq. (6.28) and can be solved by any of the implicit methods from the previous subsections. Upon convergence, the solution \( \vec{W}^{(p+1)} \) of Eq. (6.77) approximates the intermediate solution at stage \( k \) from Eq. (6.75).

Equation (6.85) on page 204:
\[ \vec{W}_I^{(k)} = \vec{W}_I^{(0)} - \frac{a_k \Delta t}{\Omega_I^{n+1}} \left[ I + \frac{3}{2 \Delta t} a_k \Delta t \vec{M}^{n+1} \right]^{-1} \]
\[ \cdot \left[ \hat{R}_I (\vec{W}^{(k-1)}) + \frac{3}{2 \Delta t} (\Omega M)_I^{n+1} \vec{W}^{(k-1)} - \vec{Q}_I \right]. \]
Chapter 7: Turbulence Modeling

Equation (7.4) on page 216:

\[ \Omega_{ij} = \frac{1}{2} \left( \frac{\partial v_j}{\partial x_i} - \frac{\partial v_i}{\partial x_j} \right). \]

Equation (7.38) on page 226 and the text below it:

\[ \tilde{S} = S + \frac{\tilde{v}}{k^2 d} f_{v2}, \]

\[ f_{v1} = \frac{\chi^3}{\chi^3 + C_{v1}}, \quad f_{v2} = 1 - \frac{\chi}{1 + \chi f_{v1}}, \]

\[ \chi = \frac{\tilde{v}}{v_L}, \]

where \( S \) stands for the magnitude of the mean rotation rate, that is,

\[ S = \sqrt{2 \Omega_{ij} \Omega_{ij}}, \]

and where \( \Omega_{ij} \) is given by Eq. (7.4). In order to avoid numerical difficulties, the term \( \tilde{S} \) must never become zero or negative. One possibility is simple limiting like \( \tilde{S} = \max(\tilde{S}, 0.3 S) \). More elaborate approaches were suggested in Ref. [49].

Equation (7.39) on page 226:

\[ f_w = g \left( \frac{1 + C_{w3}}{g^6 + C_{w3}} \right)^{1/6}, \]

\[ g = r + C_{w2}(r^6 - r), \quad r = \min \left[ \frac{\tilde{v}}{S k^2 d}, 10 \right]. \]

Equation (7.41) on page 227:

\[ C_{b1} = 0.1355, \quad C_{b2} = 0.622, \]

\[ C_{v1} = 7.1, \quad \sigma = 2/3, \quad \kappa = 0.41, \]

\[ C_{w1} = C_{b1}/\kappa^2 + (1 + C_{b2})/\sigma, \quad C_{w2} = 0.3, \quad C_{w3} = 2, \]

\[ C_{t1} = 1, \quad C_{t2} = 2, \quad C_{t3} = 1.2, \quad C_{t4} = 0.5. \]

Text above Equation (7.42) on page 227:

As pointed out in Ref. [47], it is convenient to substitute the diffusion term in Eq. (7.36), that is,

\[ \frac{1}{\sigma} \left\{ \frac{\partial}{\partial x_j} \left[ (v_L + \tilde{v}) \frac{\partial \tilde{v}}{\partial x_j} \right] + C_{b2} \frac{\partial \tilde{v}}{\partial x_j} \frac{\partial \tilde{v}}{\partial x_j} \right\} \]

by the following expression ...
Text to Initial and boundary conditions on page 228:

The initial value of \( \tilde{\nu} \) is usually taken as \( \tilde{\nu} = 0.1 \nu_L \). The same value is also specified at inflow or far-field boundaries. However, in cases where the transition term \( f_{t1} \) (and then mostly also \( f_{t2} \)) is omitted, that is, for fully turbulent flows, \( \tilde{\nu} \) should be set to 3–5 times the value of \( \nu_L \) at the inlet or far-field. At outflow boundaries, \( \tilde{\nu} \) is simply extrapolated from the interior of the computational domain. At solid walls, it is appropriate to set \( \tilde{\nu} = 0 \) and hence \( \mu_T = 0 \).

References on page 246:


Chapter 8: Boundary Conditions

Equation (8.7) on page 257:

\[
\begin{pmatrix}
\tilde{F}_{c,w}^i \Delta S_{i,2}^j = \begin{bmatrix}
0 & (n_x)_{i-1,2} (p_w)_{i-1/4} & (n_y)_{i-1,2} (p_w)_{i-1/4} & (n_z)_{i-1,2} (p_w)_{i-1/4} \\
(n_x)_{i-1,2} & 0 & (n_y)_{i-1,2} & (n_z)_{i-1,2} \\
(n_y)_{i-1,2} & (n_x)_{i-1,2} & 0 & (n_z)_{i-1,2} \\
(n_z)_{i-1,2} & (n_y)_{i-1,2} & (n_z)_{i-1,2} & 0
\end{bmatrix}
\end{pmatrix}
\frac{\Delta S_{i-1,2}}{2} + \begin{bmatrix}
0 & (n_x)_{i,2} (p_w)_{i+1/4} & (n_y)_{i,2} (p_w)_{i+1/4} & (n_z)_{i,2} (p_w)_{i+1/4} \\
(n_x)_{i,2} & 0 & (n_y)_{i,2} & (n_z)_{i,2} \\
(n_y)_{i,2} & (n_x)_{i,2} & 0 & (n_z)_{i,2} \\
(n_z)_{i,2} & (n_y)_{i,2} & (n_z)_{i,2} & 0
\end{bmatrix}
\frac{\Delta S_{i,2}}{2}.
\]

Equation (8.8) and related text on page 258:

The pressures \( (p_w)_{i-1/4} \) and \( (p_w)_{i+1/4} \) in Eq. (8.7) can be obtained by linear interpolation, for example,

\[
(p_w)_{i+1/4} = \frac{1}{4} (3p_{i,2} + p_{i+1,2}).
\]

Chapter 9: Acceleration Techniques

Point 5 of the solution steps described on page 311:

5. Multiply the residual by \( \alpha_k \Delta t / \Omega \).

Equation (9.59) on page 313 (last term in the first column):

\[
\bar{P} = \begin{bmatrix}
\rho_p & 0 & 0 & 0 & \rho_T \\
\rho_p u & \rho & 0 & 0 & \rho_T u \\
\rho_p v & 0 & \rho & 0 & \rho_T v \\
\rho_p w & 0 & 0 & \rho & \rho_T w \\
\rho_p H + \rho h_p - 1 & \rho u & \rho v & \rho w & \rho_T H + \rho h_T
\end{bmatrix}.
\]

Text on page 318:

... the condition number Eq. (9.40) is reduced (the condition number is \( C_N \approx 1.62 \)) and the ...
A.11 TRANSFORMATION FROM CONSERVATIVE TO CHARACTERISTIC VARIABLES

Matrix of the left eigenvectors Eq. (A.86) on Page 435 (term in the 4th column on the 2nd row):

\[
\bar{T}^{-1} = \begin{bmatrix}
    n_x a_5 - (n_z v - n_z w) \rho^{-1} & n_x a_1 u c^{-2} & n_x a_1 v c^{-2} + n_x \rho^{-1} \\
    n_y a_5 - (n_z w - n_z u) \rho^{-1} & n_y a_1 u c^{-2} - n_y \rho^{-1} & n_y a_1 v c^{-2} \\
    n_z a_5 - (n_y u - n_y v) \rho^{-1} & n_z a_1 u c^{-2} + n_z \rho^{-1} & n_z a_1 v c^{-2} - n_z \rho^{-1} \\
    a_2 (\phi - cV) & -a_2 (a_1 u - n_x c) & -a_2 (a_1 v - n_x c) \\
    a_2 (\phi + cV) & -a_2 (a_1 u + n_x c) & -a_2 (a_1 v + n_x c) \\
    n_x a_1 w c^{-2} - n_y \rho^{-1} & -n_x a_1 c^{-2} \\
    n_y a_1 w c^{-2} + n_z \rho^{-1} & -n_y a_1 c^{-2} \\
    n_z a_1 w c^{-2} & -n_z a_1 c^{-2} \\
    -a_2 (a_1 w - n_z c) & a_1 a_2 \\
    -a_2 (a_1 w + n_z c) & a_1 a_2
\end{bmatrix}.
\]