6. Debugging Tools

6.1 Turbulence Model Diagnostics (DEBUG=1)

An OVERFLOW turbulent quantity debug option is included by specifying the **&GLOBAL** NAMELIST input parameter **DEBUG**=1. Turbulent parameters of interest are written to a “fake Q file” **q.turb**. Familiarity with respective turbulence model quantities is required if meaningful insight is to be expected. Different turbulent quantities are written to the **q.turb** file depending on the turbulence model selected in the OVERFLOW input file.

The file **q.turb** is based on the flow solution input in **q.restart**. The NAMELIST input expected when using **DEBUG**=1 is identical to the input required to continue the current OVERFLOW solution using the **RESTRT**=.TRUE. option. Note that the **DEBUG**=1 option does not take a complete step through the solution, so **NSTEPS** is ignored in the NAMELIST input.

A detailed listing of parameters written to **q.turb** is given in the Tables 6.1-6.6. The row beginning with *(J,K,LS,_)* denotes turbulent quantities stored at the surface, in this case L is the normal direction. The row beginning with *(J,K,L,_)* denotes turbulent quantities stored throughout the field defined by the &**VISINP** section of the NAMELIST input.

For the Baldwin-Barth and Spalart-Allmaras R_T models, a turbulence index is returned at the surface in Q5. This variable ramps from 0 (laminar flow) to 1 (turbulent flow), with a value of -2 indicating invalid data ($|\omega|=0$, for example).

When using PLOT3D, it is critical to remember that only grid functions and explicit Q functions are meaningful. The **q.turb** file should be read using:

read/unformatted/mgrid/blank/nocheck/x=grid.in/q=q.turb

The **/nocheck** option is important, in that without it, PLOT3D will interpret the Q file as containing flow variables, and may modify values to avoid negative density or pressure. Use **/ieee** instead of **/unformatted** for double-precision grid and Q files.

Table 6.1 Debug output for Baldwin-Lomax and Degani-Schiff turbulent quantities (NQT=0 and ITTYP=1).

PLOT3D Funct	*100*	*160*	*161*	*162*	*163*
Q Value	*Q1*	*Q2*	*Q3*	*Q4*	*Q5*
(J,K,LS,_)	F_{max}	y^+	$\lvert\omega\rvert$	μ_w	-
(J,K,L,_)	$F(y)$	y	$\lvert\omega\rvert$	μ_t	F_{max} *location* *1 inner* *2 outer* *3 outer wake* *-1* F_{max}

Table 6.2 Debug output for Baldwin-Lomax and wake model turbulent quantities (NQT=0 and ITTYP=11).

PLOT3D Funct	*100*	*160*	*161*	*162*	*163*
Q Value	*Q1*	*Q2*	*Q3*	*Q4*	*Q5*
(J,K,LS,_)	F_{wake}	$\frac{u_{dif}}{\lvert\Omega\rvert_{max}}$	$\lvert\omega\rvert$	μ_t	$\lvert\omega\rvert_{max}$ *location*
(J,K,L,_)	$\lvert\omega\rvert_{max}$	y	$\lvert\omega\rvert$	μ_t	$\lvert\omega\rvert_{max}$ *location* *4 wake* *-1* $\lvert\omega\rvert_{max}$

Table 6.3 Debug output for Baldwin-Barth R_T 1-equation model turbulent quantities (NQT=100).

PLOT3D Funct	*100*	*160*	*161*	*162*	*163*
Q Value	*Q1*	*Q2*	*Q3*	*Q4*	*Q5*

(J,K,LS,_)	$c_\mu D_1 D_2$	y^+	$\|\omega\|$	μ_t	*Turbulence index*
(J,K,L,_)	$c_\mu D_1 D_2$	$f_2(y^+)$	$\|\omega\|$	μ_t	*Transition factor*

Table 6.4 Debug output for Spalart-Allmaras R_T 1-equation model turbulent quantities (NQT=101,102).

PLOT3D Funct	*100*	*160*	*161*	*162*	*163*
Q Value	*Q1*	*Q2*	*Q3*	*Q4*	*Q5*
(J,K,LS,_)	f_{v1}	y^+	$\|\omega\|$	μ_t	*Turbulence index*
(J,K,L,_)	f_{v1}	y	$\|\omega\|$	μ_t	*Trip/Transition factor*

Table 6.5 Debug output for k-ω 2-equation model turbulent quantities (NQT=202 or 204).

PLOT3D Funct	*100*	*160*	*161*	*162*	*163*
Q Value	*Q1*	*Q2*	*Q3*	*Q4*	*Q5*
(J,K,LS,_)	ω	y^+	S_{ij}^2	μ_t	*Turbulence index*
(J,K,L,_)	ω	y	S_{ij}^2	μ_t	k

Table 6.6 Debug output for SST 2-equation model turbulent quantities (NQT=203 or 205).

PLOT3D Funct	*100*	*160*	*161*	*162*	*163*
Q Value	*Q1*	*Q2*	*Q3*	*Q4*	*Q5*
(J,K,LS,_)	ω	y^+	F_1	μ_t	*Turbulence index*
(J,K,L,_)	ω	y	F_1	μ_t	k

6.2 Timestep Diagnostics (DEBUG=2)

A diagnostic "fake Q file" **q.time** can be generated by running OVERFLOW with the **&GLOBAL** input parameter **DEBUG**=2. Running the code with **DEBUG**=2 requires the same input files as the **DEBUG**=1 option described above. The five field quantities returned in **q.time** are (Δt, CFL_j, CFL_k, CFL_l, *and* CFL_{max}). These correspond to the NAMELIST **&TIMACU** variables **ITIME**, **DT**, **CFLMIN**, and **CFLMAX** specified in the input file.

6.3 Residual Diagnostics (DEBUG=3)

A diagnostic "fake Q file" **q.resid** can be generated by running OVERFLOW with the **&GLOBAL** input parameter **DEBUG**=3. Running the code with **DEBUG**=3 requires the same input files as the **DEBUG**=1 option described above. The five field quantities returned in **q.resid** are the residuals of the five conserved variables.

6.4 Solution Adaption Information (DEBUG=4)

A diagnostic "fake Q file" **q.errest** can be generated by running OVERFLOW with the **&GLOBAL** input parameter **DEBUG**=4. The first three field quantities returned in **q.errest** are the error estimation sensor function; the marker array indicating whether the local grid resolution should be coarsened (-1), refined (+1), or maintained (0); and $\log_{10}$ of the sensor function. Other field quantites are currently not used.

6.5 Reynolds Stress Turbulence Model Diagnostics (DEBUG=5)

A diagnostic "fake Q file" **q.reystr** can be generated by running OVERFLOW with the **&GLOBAL** input parameter **DEBUG**=5. Six field quantities are returned: τ_{11}, τ_{21}, τ_{31}, τ_{22}, τ_{32}, τ_{33}. These include quadratic constitutive relation (QCR) terms, if appropriate.