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PART 1 – CONTROLLED TEST SETUP

Test case : **Turbulent buoyancy flow in a cavity – 2000/1/4**
Document Version 1.1

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Case: **Turbulent buoyancy flow in a cavity – 2000/1/4**

User details	
Run by: Date: Phone no: email:	Address:

Fire modelling Software

SMARTFIRE	CFX	PHOENICS			

Version/build number_____
Date of release_____

Operating System

Windows 95/98/2000	Windows NT	Unix	Dos	

Version/build number_____

Machine

PC	Unix Workstation	

CPU:
Memory:

Case description

This test case examines the turbulence model, turbulent heat transfer and buoyancy model of a CFD fire modelling code. The test case is a standard test case that has been used by a number of other investigators*.

The geometry used for this case is depicted in Figure 1 below.

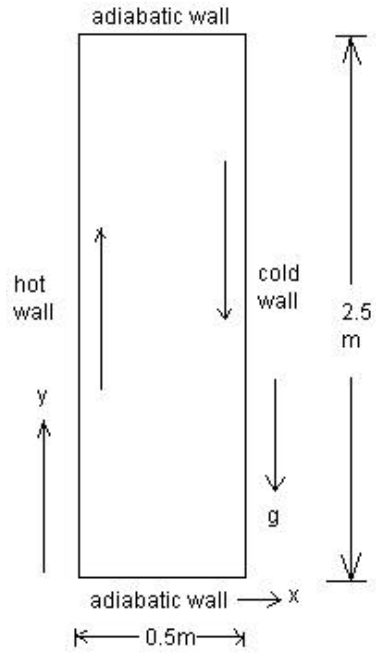

Figure 1 – Configuration for buoyancy flow in a duct

The flow is fully turbulent, buoyant and fully compressible but with no radiation heat transfer. The hot wall is at a temperature of 353K and the cold wall is at 307.2K. The other walls are adiabatic. The acceleration due to gravity (g) is –9.81m/s

*L. Davidson, "Calculation of the turbulent buoyancy-driven flow in a rectangular cavity using an efficient solver and two different low Reynolds number κ-ε turbulence models", Numerical Heat Transfer, vol. 18, pp. 129-147, 1990.

Fluid properties

conductivity is 2.852158e-02 (W/mK)
density is 1.071 (kg/m^3) determined by ideal gas law as fully compressible.
specific heat is 1.008e+03 (J/kgK)
laminar viscosity is 2.0383e-05 (kg/ms)
thermal expansion is 3.029385e-03 (1/K).

Required Results
The results should be supplied as graphs and as Excel97 worksheets

These results will be compared against experiment and across codes.

The v-velocity profile at y/H = 0.5
The normalised temperature profile at y/H = 0.5 and x/L = 0.5
where $T_{normalised} = (T_{actual} - T_{cold})/(T_{hot} - T_{cold})$

The turbulent fluctuations, $\sqrt{k}$, at y/H = 0.5 The turbulent viscosity scaled with the laminar viscosity at y/H = 0.5. where L is full length across the x direction of the duct (0.5m) and H is the full height of the duct in the y direction (2.5m).

CFD set up

1D	2D	3D

Transient	Steady State

Differencing Schemes

Temporal:

Fully Implicit	Crank-Nicolson	Explicit	Exponential	

Spatial:

Hybrid	Central Difference	Upwind		

Notes:

Physical Models

Radiation Model *(if not listed please specify in the space provided)*

None	Six flux	Discrete Transfer	Monte Carlo	Radiosity	

Notes:

Parameters

Turbulence model *(if not listed please specify in the space provided)*

Laminar	k- ε	buoyancy modified k-ε	RNG	

Notes:

Turbulence Parameters*:

C_μ	σ_k	σ_ε	$C_{1\varepsilon}$	$C_{2\varepsilon}$	C_3
0.09	1.0	1.3	1.44	1.92	1.0

*If different parameters are being used please specify in the table above.

Combustion Model *(if not listed please specify in the space provided)*

none	Volumetric heat source	Mixed is burnt	Eddy break up
Magnussen soot model			

Combustion Parameters:

Compressibility

Incompressible	Boussinesq	Weakly compressible	Fully compressible

Compressibility Parameters:

External Pressure 1.01325e+05 Pa

Buoyancy

Yes	No

Gravity	-9.81m/s in the v-velocity direction.

Material Properties

Material Name	Air
Density	Determined by compressibility (Ideal Gas Law) Molecular Weight of air is 29.35
Laminar Viscosity	2.0383e-05 kg/m.s
Conductivity	2.852158e-02 W/m.K
Specific heat capacity	1008.0 J/kg.K

Initial Values

U-VELOCITY	1.0e-6
V-VELOCITY	1.0e-6
W-VELOCITY	0.0
PRESSURE	0.0
TEMPERATURE	307.2

KINETIC ENERGY	0.0034
DISSIPATION RATE	0.001369

Boundary conditions
hot wall (t_h): constant temperature (353.0 K)
cold wall(t_c): constant 307.2 (K).
The other walls are adiabatic.

Mesh

The cell budget is 14641(121×121x1) with non-uniformly distributed mesh. There is no mesh diagram due to the fineness of the mesh.

```
X 0.0 0.001819 0.004179 0.006797 0.0096 0.012548 0.015616
0.018789 0.022055 0.025403 0.028827 0.03232 0.035877
0.039494 0.043167 0.046892 0.050668 0.054492 0.058361
0.062273 0.066226 0.070219 0.074251 0.078319 0.082423
0.086561 0.090732 0.094936 0.099171 0.103436 0.107731
0.112054 0.116406 0.120784 0.12519 0.129621 0.134078
0.138559 0.143065 0.147595 0.152148 0.156724 0.161322
0.165942 0.170583 0.175246 0.17993 0.184634 0.189358
0.194102 0.198865 0.203647 0.208448 0.213268 0.218105
0.222961 0.227834 0.232725 0.237633 0.242558 0.2475 0.2525
0.257442 0.262367 0.267275 0.272166 0.277039 0.281895
0.286732 0.291552 0.296353 0.301135 0.305898 0.310642
0.315366 0.32007 0.324754 0.329417 0.334058 0.338678
0.343276 0.347852 0.352405 0.356935 0.361441 0.365922
0.370379 0.37481 0.379216 0.383594 0.387946 0.392269
0.396564 0.400829 0.405064 0.409268 0.413439 0.417577
0.421681 0.425749 0.429781 0.433774 0.437727 0.441639
0.445508 0.449332 0.453108 0.456833 0.460506 0.464123
0.46768 0.471173 0.474597 0.477945 0.481211 0.484384
0.487453 0.4904 0.493203 0.495821 0.498181 0.5
Y 0.0 0.002657 0.007516 0.013808 0.021258 0.029709 0.039054
0.049214 0.060128 0.071747 0.084031 0.096946 0.110462
0.124553 0.139198 0.154375 0.170067 0.186257 0.202931
0.220075 0.237676 0.255723 0.274204 0.293111 0.312433
0.332162 0.35229 0.372808 0.393711 0.414989 0.436638
0.458651 0.481022 0.503745 0.526815 0.550227 0.573976
0.598057 0.622466 0.647198 0.672249 0.697615 0.723293
0.749278 0.775567 0.802156 0.829043 0.856223 0.883694
0.911453 0.939496 0.967822 0.996426 1.025307 1.054461
1.083887 1.113582 1.143543 1.173767 1.204254 1.235 1.265
1.295746 1.326233 1.356457 1.386418 1.416113 1.445539
1.474693 1.503574 1.532178 1.560504 1.588547 1.616306
1.643777 1.670957 1.697844 1.724433 1.750722 1.776707
1.802385 1.827751 1.852802 1.877534 1.901943 1.926024
```

```
1.949773 1.973185 1.996255 2.018978 2.041349 2.063362
2.085011 2.106289 2.127192 2.14771 2.167838 2.187567
2.206889 2.225796 2.244277 2.262324 2.279925 2.297069
2.313743 2.329933 2.345625 2.360802 2.375447 2.389538
2.403054 2.415969 2.428253 2.439872 2.450786 2.460946
2.470291 2.478742 2.486192 2.492484 2.497343 2.5
Z 0.0 1.0
```

Model Definition files

Convergence

Please specify your convergence criteria including type of error estimator and tolerance value for each variable

Runtime

Results files/Archiving:

Document cross-reference:

User Guides, etc

Comments