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IEA-Annex 20

Airflow Patterns Within Buildings

Task 1.10

Two- and Three- Dimensional Computer Codes Developed For Applications Other Than Room Airflows

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Task 1.7

The following table presents a literature review of the turbulence models developed for applications other than room airflows. Abbreviations and references are listed at the end of the table.

General Comments:

- The K-E model and up-wind scheme appear to be the most widely used techniques.
- A large number of literature on the PHOENICS code of CHAM Ltd (and its twin the JASMINE code) were excluded because the Annex participants are well familiar with this code and its diverse applications.
- Similarly, the participants are fairly familiar with the work of the Imperial college group which evidently forms the basis and sets the trend for turbulence modelling.

The following codes are available commercially in North America.

Code/Author Organiz.,country, yr.	Turbulence Model	Numerical Method	Application
NISA/3D - Fluid	K-E	UW	- General application Fluid flow and convective heat transfer - Marketed by Engineering Mechanics Research Corp., USA Tel: (313) 643-6222, Tlx: 469232
MicroCOMPACT	K-E	SIMPLER algorithm	- General 2-D analysis of convective transport involving fluid flow, heat and mass transfer, chemical reaction - Developed by Patankar,S.V. - Runs on IBM PC,XT,AT or compatible, - A graphics package is available - Cost approx. $3500 US, - Marketed by Innovative Research Inc., Minnesota, USA, Tel: (612) 559-6067

The following codes were developed for industrial applications (nuclear, aerospace, automotive) in North America

Code/Author Organiz.,country, yr.	Turbulence Model	Numerical Method	Application
VARR2	K and TKV	SMAC	2-D transient flow with slight density variations
2DMOTH AECL, Canada	K-E	SIMPLE algorithm	- Moderator flow pattern within a Candu reactor vessel (involves jet and buoyancy driven flows) - A modified version of TEACH code - currently, using Phoenics code
FONS-TURB, MODCIRC Ont. Hydro, Canada	K-E	UW	- 2-D buoyancy driven air circulation in a cavity - Moderator flow in a Candu reactor vessel
Kaul, U.& Kwak, D. NASA, USA, 1986	K-E (low & high Re models)		- A general solver for internal flows(compressible/incompressible) with a large separated flow region - Developed for space shuttle applications - Paper presents results for two cases: internal channel flow and channel flow with a 2:3 sudden expansion - Lists several NASA literature on the subject.

Kwon,O. et al. General Motors Corp. USA, 1988	Algebraic MLM	BTM	2-D compressible, unsteady boundary layers
Spezialc, Ċ. NASA, USA, 1985	2nd order closure models		Examines various 2nd-order closure models for the case of fully developed channel flow in a rapidly rotating framework. Results are compared to K-E and K-L predictions.

The following are selected recent publications (listed chronologically)

Code/Author Organiz., country, yr.	Turbulence Model	Numerical Method	Application
Kim, Y. & Chung, M. Inha U., Korea, 1987	K-E model & variable EVM		Presents a modified variable eddy viscosity model (variable C_μ) for swirling flows.
Nikjooy, M. et al. Arizona, USA 1987	K-E, algebraic stress & RSM closure models		- Reactive & non-reactive combustor flows with & without swirl - For NASA applications
Tzabira, G.D. Athens U., Greece 1987	K-E model & three EVM of C&S and H	UW	Studies the performance of three EVM for the case of the flow-field at the stern of a body of revolution
Warfield, M. et al. Pen. S.U., USA, 1987	K-E & ARSM (variable C_μ)	SM	Developing & fully developed channel flow with high rotation
Deriat, E. et al. ONERA, France, 1986	K-E & MLM		presents mathematical analysis of turbulent boundary layer flows
Humphrey, J. et al. Calif. U., Berkeley USA, 1986	K-E and ARSM & Boussinesq approx.	HUWCD	- Free & mixed convection, low Re, flow in a heated cavity, - a heated vertical flat plate
Nakayama, A. et al. Shizuoka, U., Japan, 1986, 1984	K-E model & stress model of L&Y	SIMPLE algorithm	- developed flow & heat transfer in ducts of cross-shaped cross section - 3D developing flow in a square duct

Abbreviations

ARSM	Algebraic Reynolds Stress Models
BTM	Block Tridiagonal Matrix
BTVM	Boussinesq's Turbulent Viscosity Model
C&S and H	Cebeci,T. & Smith, A.M.O. and Huang, T.T.
CNTI	Crank Nicolsen Type Implicity Scheme
EVM	Eddy Viscosity Model
HUWCD	Hybrid Up-Wind Central Difference
H & L	Hanjalic, K. and Launder, B.E.
LES	Large Eddy Simulation
L & Y	Launder, B.E., and Ying, W.M.
MLM	Mixing Length Model
RSM	Reynolds Stress Closure Model
SIMPLE / SIMPLER	Semi-Implicit Method for Pressure-Linked Equations / SIMPLE Reviced of Patankar, S.V. and Spalding, D.B.
SMAC	Simplified Marker and Cell Method
SM	Space Marching Method (single pass streamwise integration)
TKV	Turbulence Kinematic Viscosity model
UW	Up-Wind Scheme of Gosman et al.

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