GMS-DFC GROUP

MODELING AND SIMULATION OF FLUID DYNAMICS AND COMBUSTION

SHORT PRESENTATION

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UFRGS-IM/DMPA

GRADUATE PROGRAMS IN

- APPLIED MATHEMATICS
- CHEMICAL ENGINEERING

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SET OF GOVERNING EQUATIONS SOME NATURAL PHENOMENA

LARGE-EDDY SIMULATION – NAVIER WITH MIXING

$$\frac{\partial}{\partial t}(\bar{\rho}\tilde{u}_i) + \frac{\partial}{\partial x_j}(\bar{\rho}\tilde{u}_i\tilde{u}_j) = \frac{1}{M^2}\frac{\partial \bar{p}}{\partial x_i} + \frac{\partial}{\partial x_j}(\frac{\mu_T}{R_e}\tilde{\tau}_{ij})$$

$$\frac{\partial}{\partial t}(\bar{\rho}\tilde{Z}) + \frac{\partial}{\partial x_j}(\bar{\rho}\tilde{u}_j\tilde{Z}) = \frac{\partial}{\partial x_j}(\frac{\mu_T}{S_c}\frac{\partial \tilde{Z}}{\partial x_j})$$

$$\frac{\partial}{\partial t}(\bar{\rho}\tilde{Z}''^2) + \frac{\partial}{\partial x_j}(\bar{\rho}\tilde{u}_j\tilde{Z}''^2) = \frac{\partial}{\partial x_j}(\frac{\mu_T}{S_c}\frac{\partial \tilde{Z}''^2}{\partial x_j}) + 2\rho D_T(\nabla\tilde{Z})^2 - \bar{\rho}\tilde{\chi}$$

$$\frac{\partial}{\partial t}(\bar{\rho}\tilde{h}) + \frac{\partial}{\partial x_j}(\bar{\rho}\tilde{u}_j\tilde{h}) = \frac{\partial}{\partial x_j}(\frac{\mu_T}{P_r}\frac{\partial \tilde{h}}{\partial x_j})$$

SET OF GOVERNING EQUATIONS SOME NATURAL PHENOMENA

CHEMISTRY

$$\frac{\partial \tilde{Y}_i}{\partial t} - \frac{a\aleph}{2L_e}\frac{\partial^2 \tilde{Y}_i}{\partial Z^2} = \dot{w}$$

$$\tilde{h} = \sum_{i=1}^{n} \tilde{Y}_i h_i \tilde{T})$$

CONTROL

$$\dot{X} = AX + BU$$

$$Y = CX$$

$$U = -KX$$

SOME RESULTS

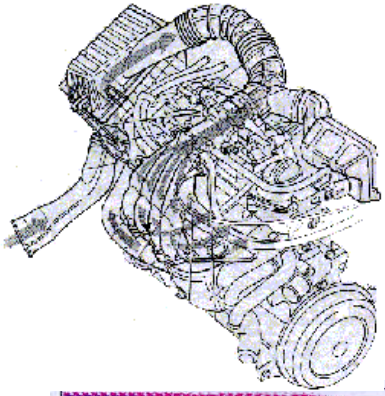
- (IN)COMPRESSIBLE SUBSONIC FLOWS
- TRANSONIC/ SUPERSONIC FLOWS
- INCOMPRESSIBLE INTERNAL FLOWS
- INTERNAL FLOWS - NON NEWTONIAN
- EXPANSIONS - NON NEWTONIAN FLOWS
- CONVERGENCE ACCELERATION/ CONTROL
- COMBUSTION CHEMISTRY
- COMBUSTION/LAMINAR-TURBULENT FLAMES
- GRANULAR MEDIUM / DRYING PROCESS
- NUCLEAR REACTOR SAFETY
- POROUS MEDIA
- NATURAL FLOWS

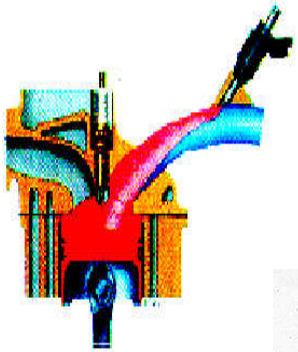
(IN)COMPRESSIBLE SUBSONIC FLOWS

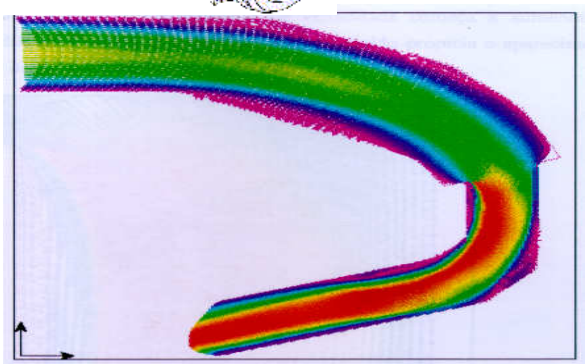
INTAKES

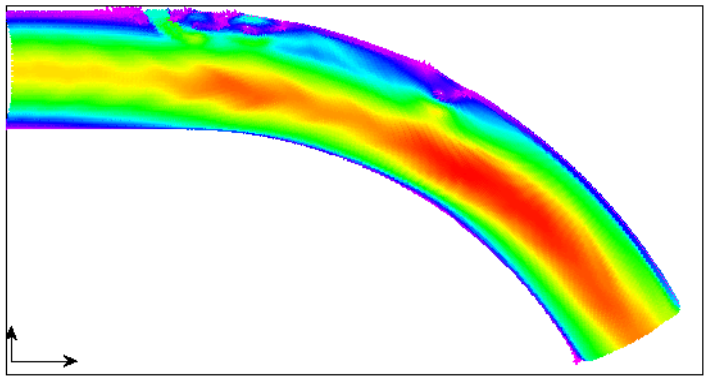
FANS/PUMPS

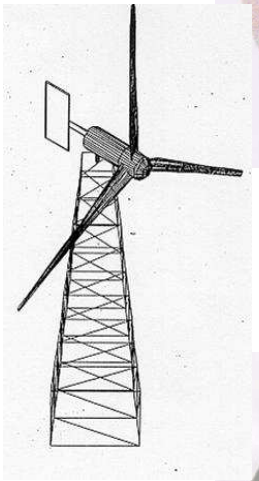
AUTOMOBILES

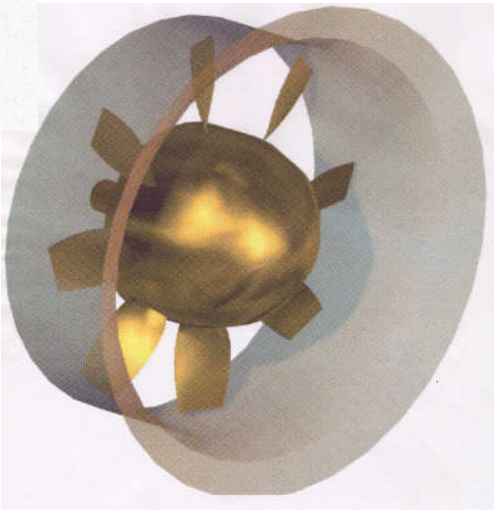




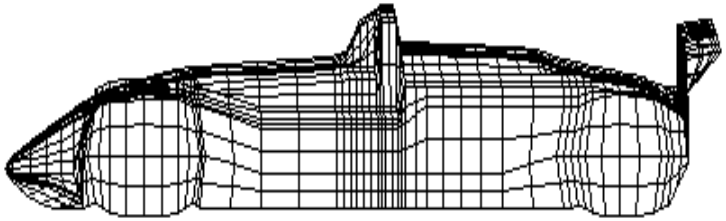


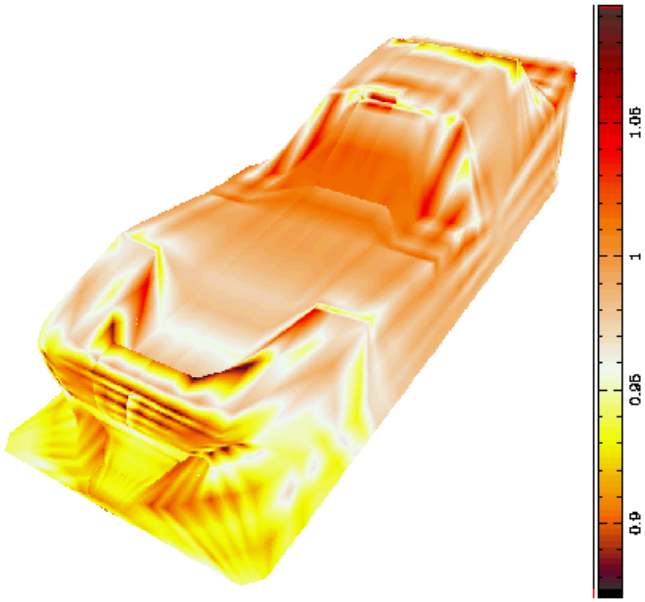






200 Km/h

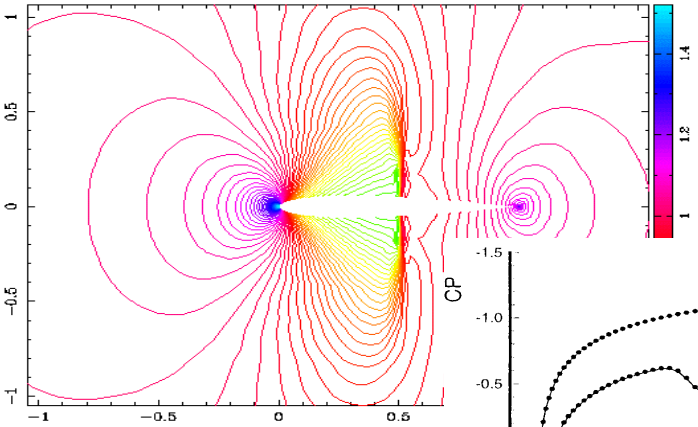


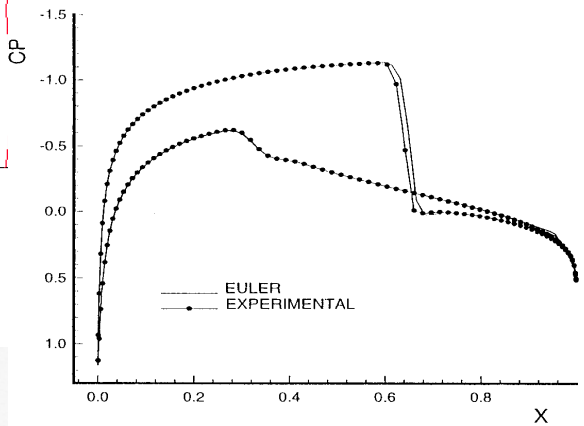


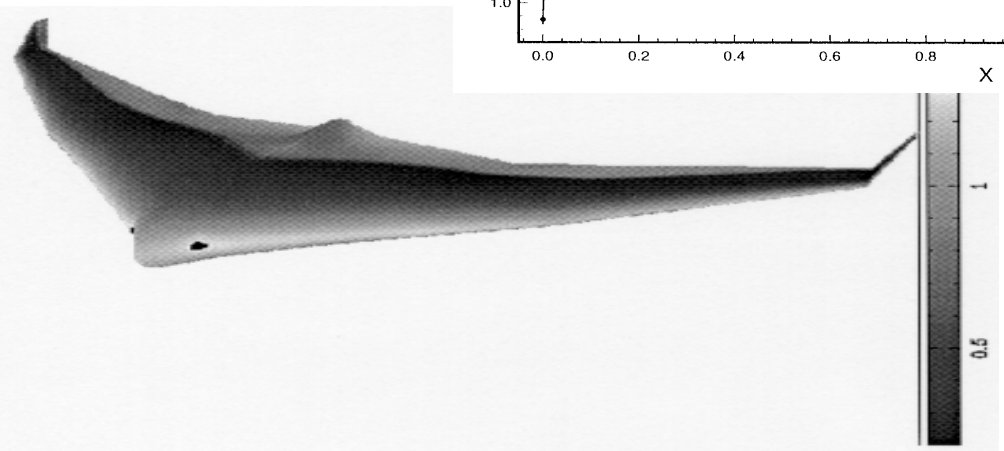
TRANSONIC/ SUPERSONIC FLOWS

AIRPLANES

MACH – 0.8

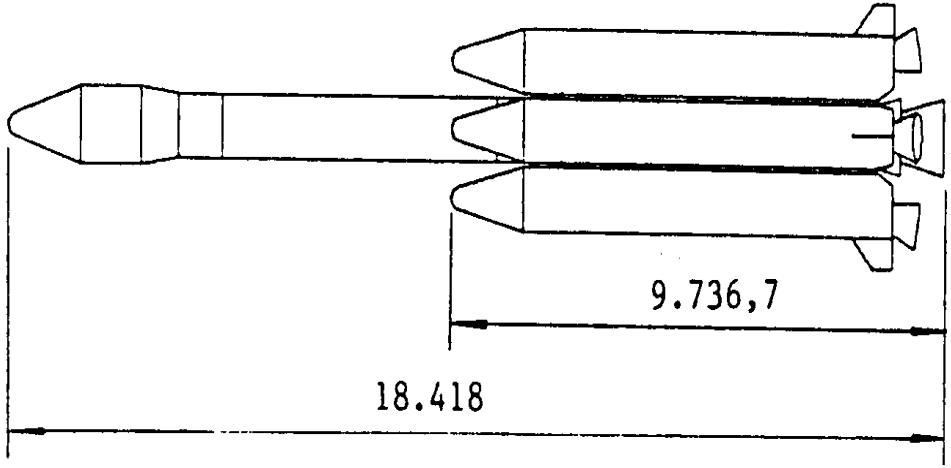


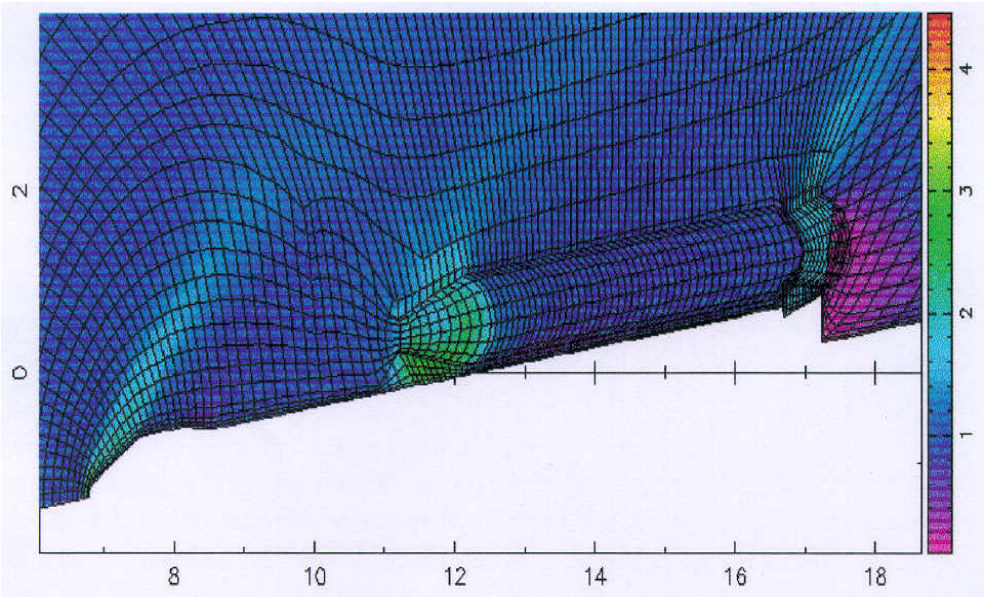




LAUNCH VEHICLE

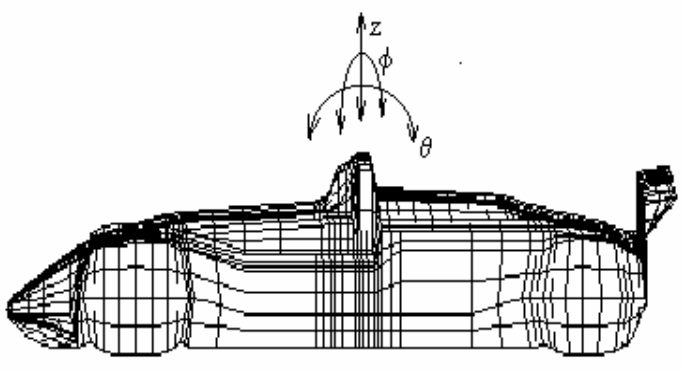
Vls - MACH = 2.0

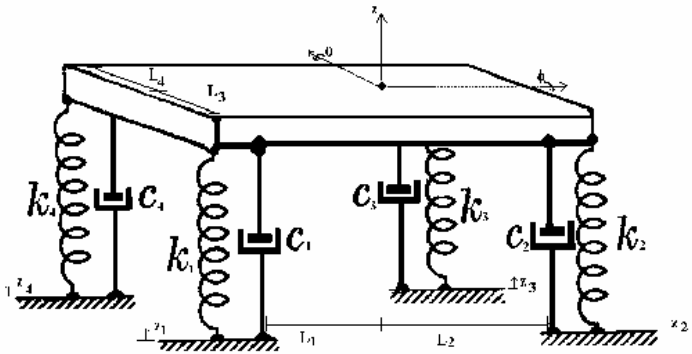


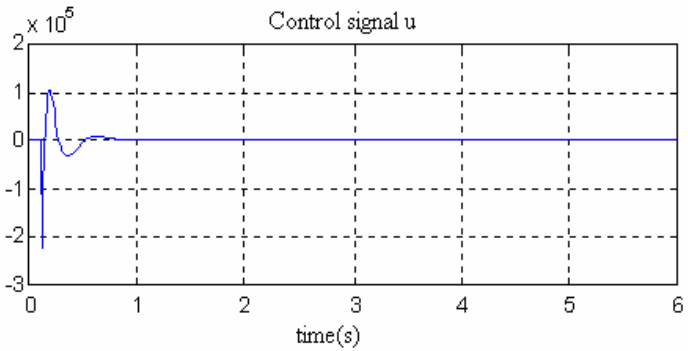


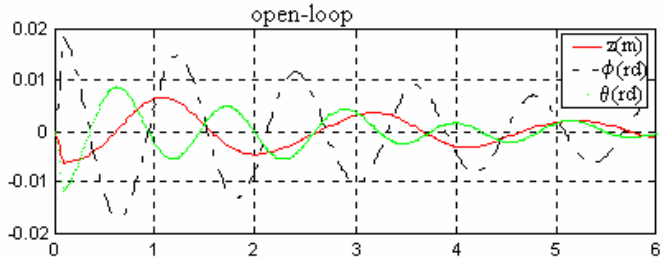
SUSPENSIONS CONTROL

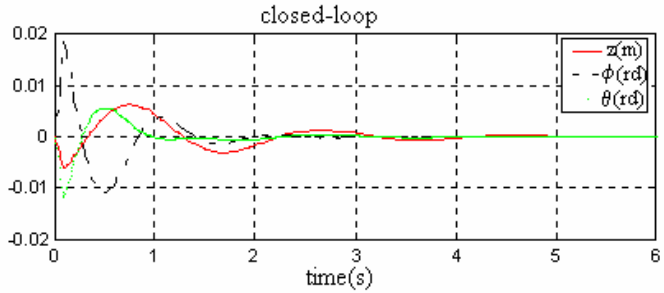
AUTOMOBILES



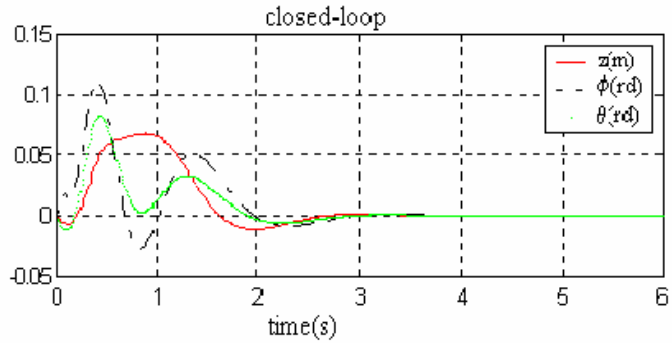




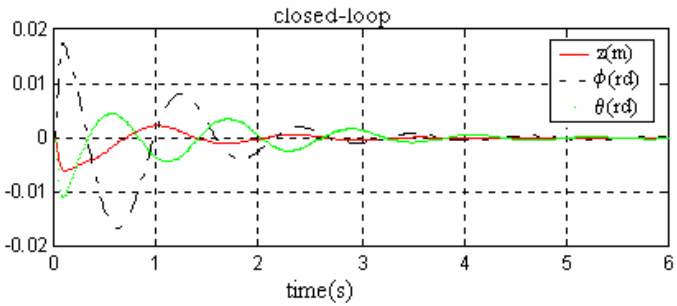




CLASSIC



POLES PLACEMENT



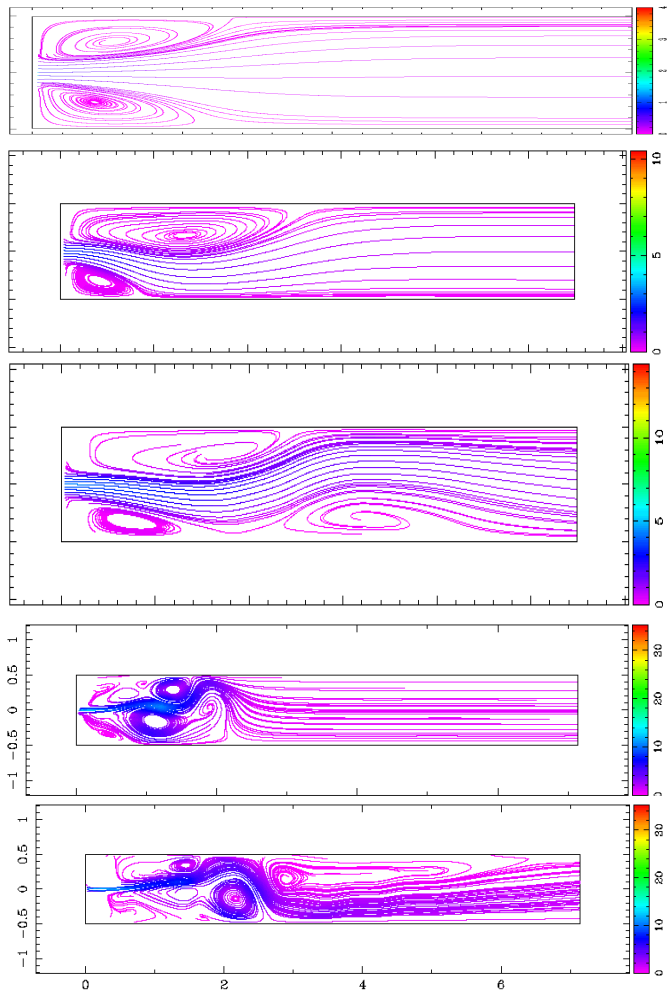
LQR

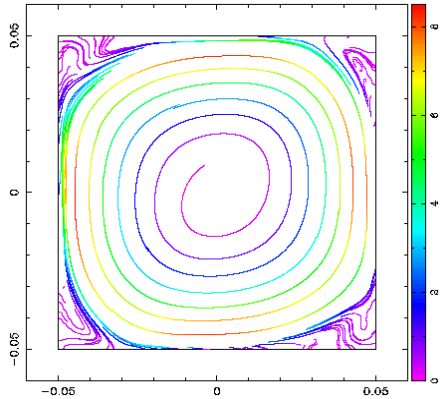
INCOMPRESSIBLE INTERNAL FLOWS

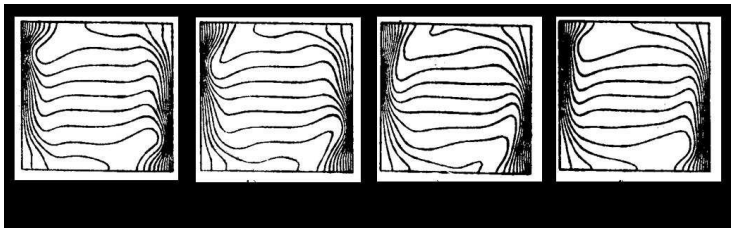
EXPANSIONS

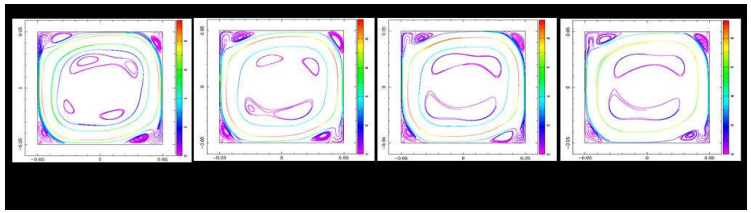
CAVITIES

SOLAR BATTERY

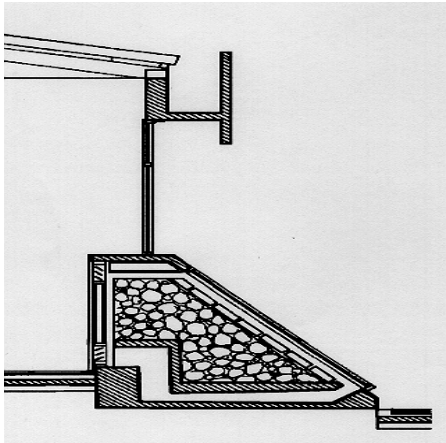


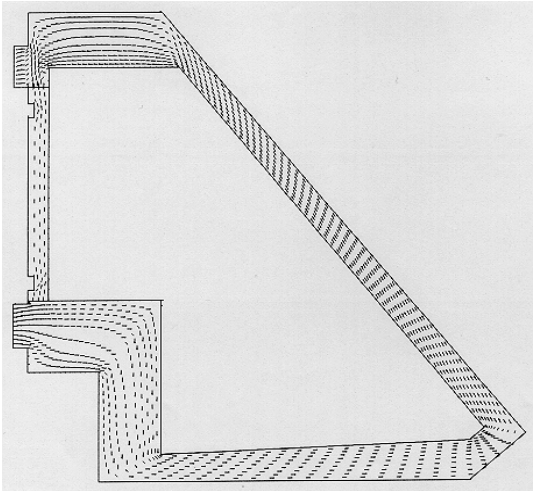






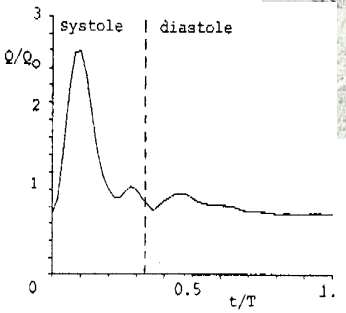
t=10°

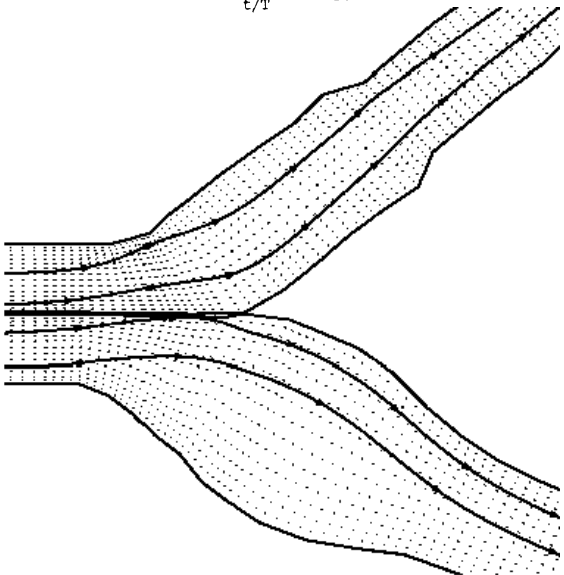




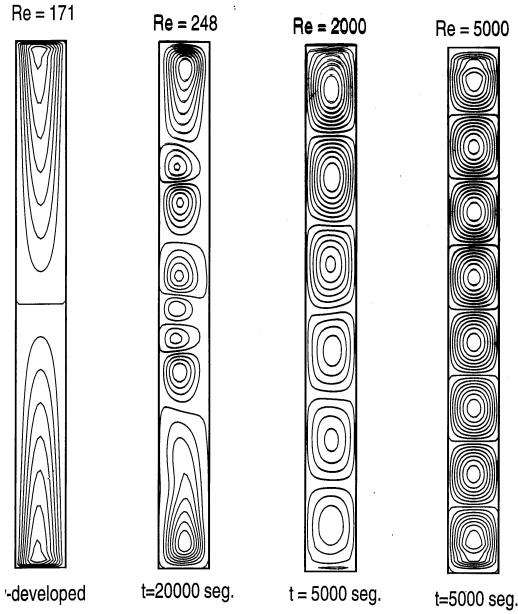
INTERNAL FLOWS - NON NEWTONIAN

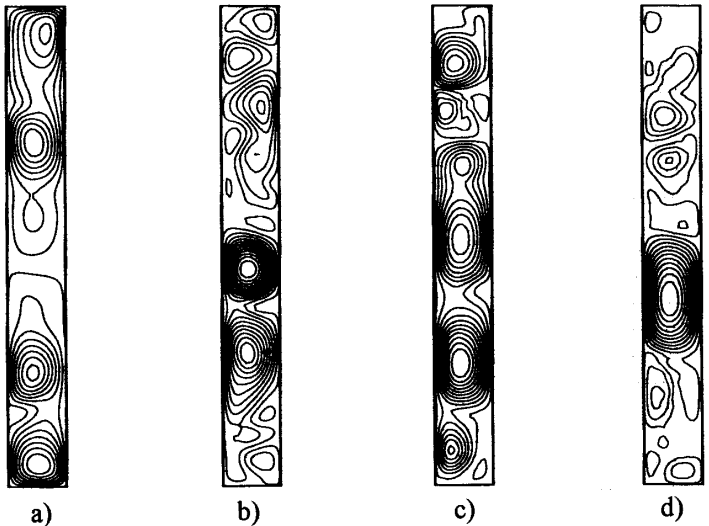
CAROTID





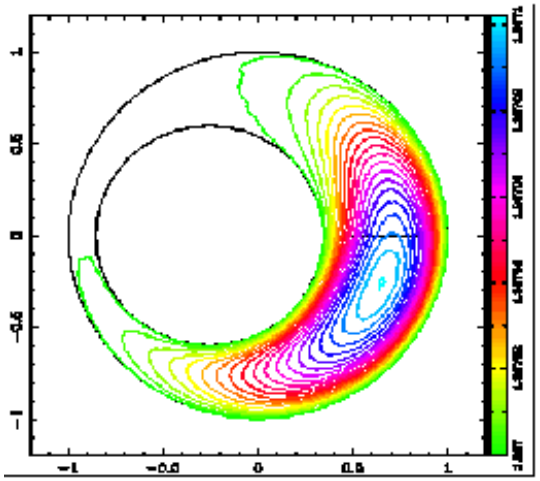
ROTATORY MACHINES



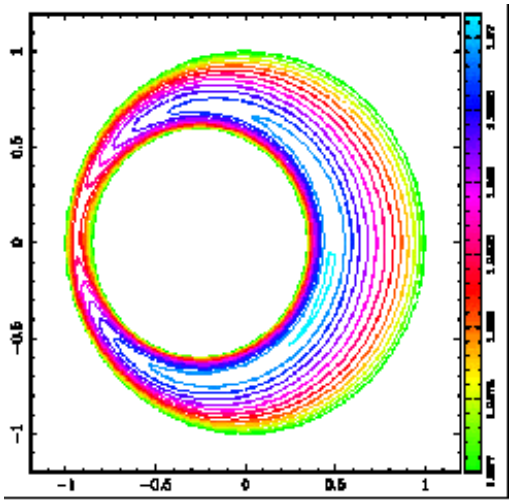


JOURNAL BEARINGS

Newtonian



Non Newtonian



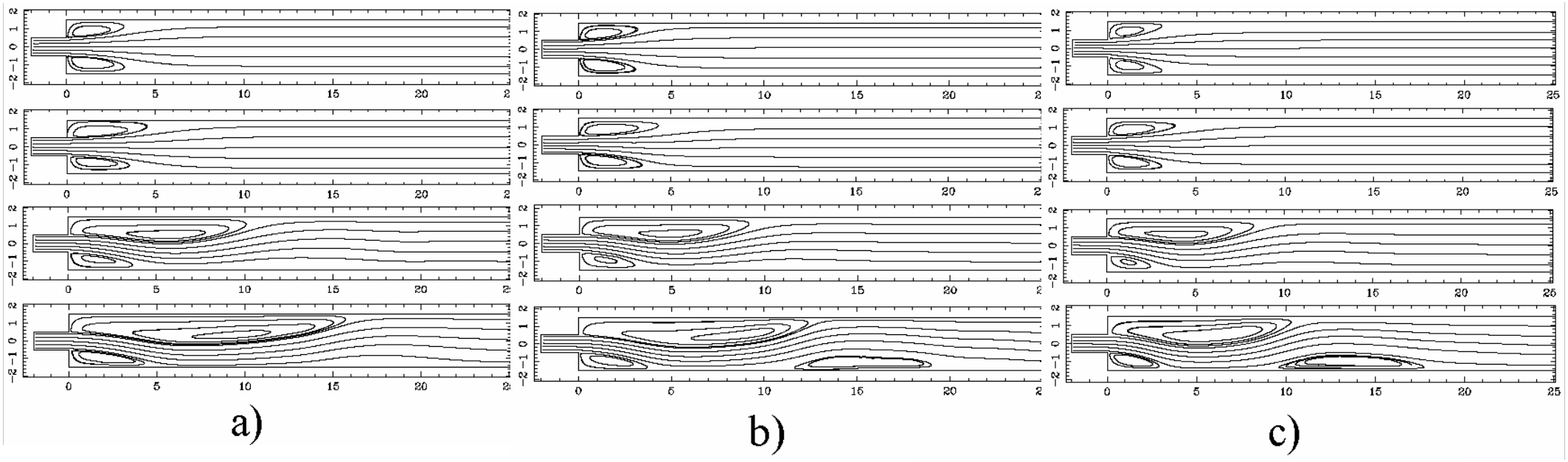
Re=10, De=4,2-3, Ec=0,002

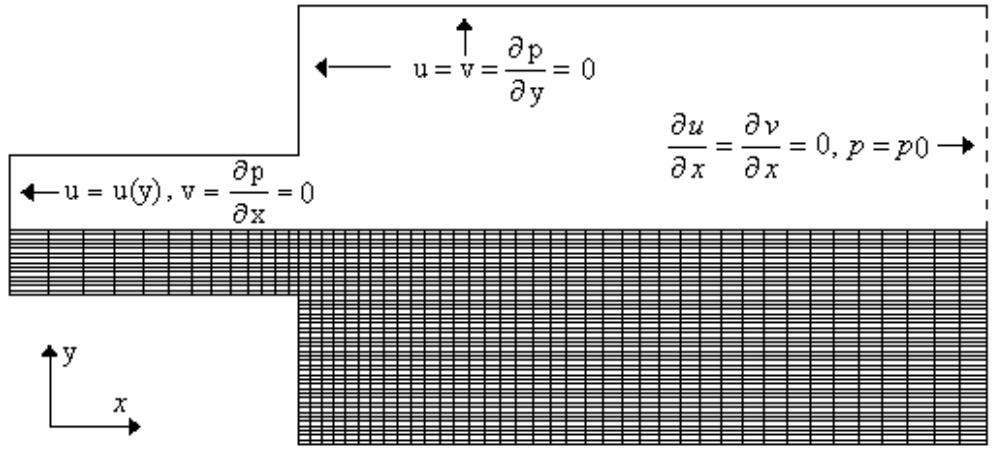
EXPANSION - NON NEWTONIAN FLOWS

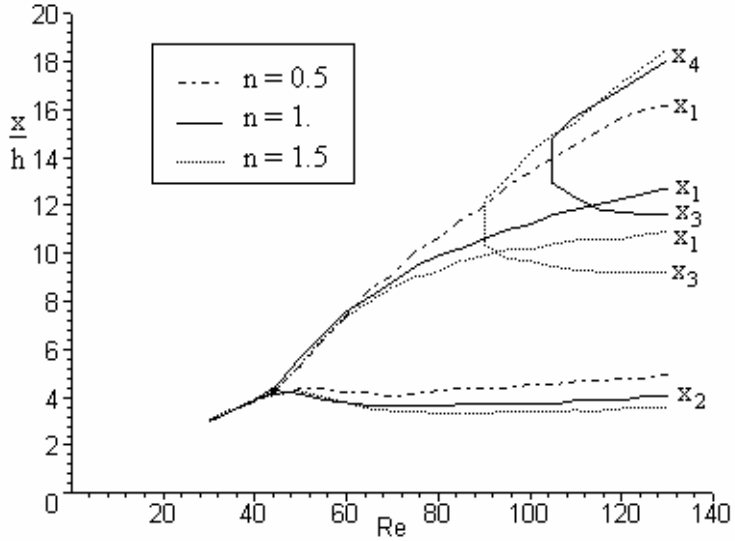
PSEUDOPLASTIC: n = 0.5

NEWTONIAN: n = 1

DILATANT: n = 1.5



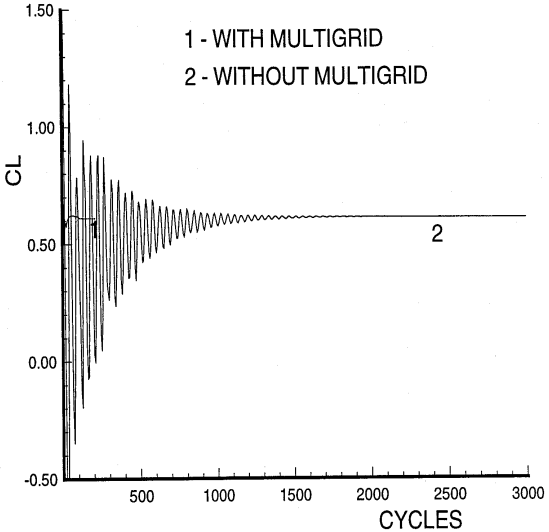


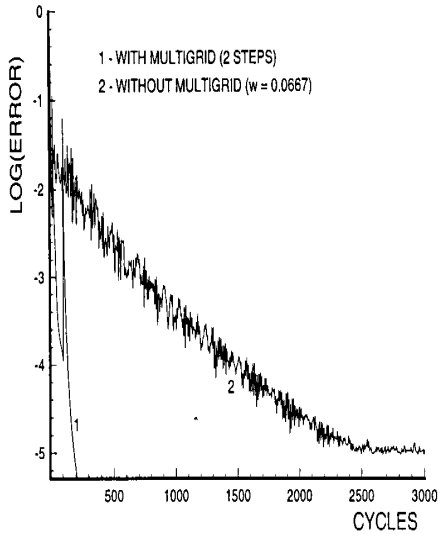


CONVERGENCE ACCELERATION NUMERICAL/MATHEMATICAL TREATMENT

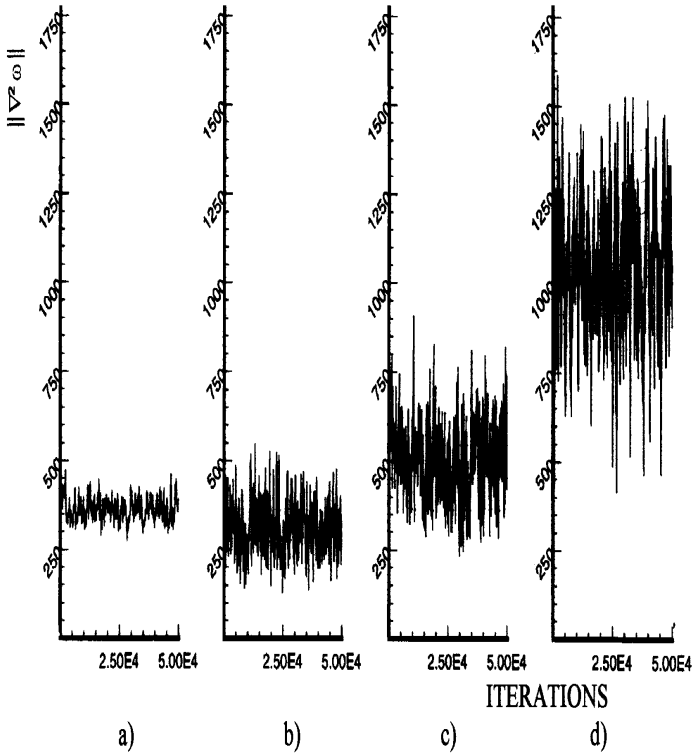
ACCELERATION

Convergence



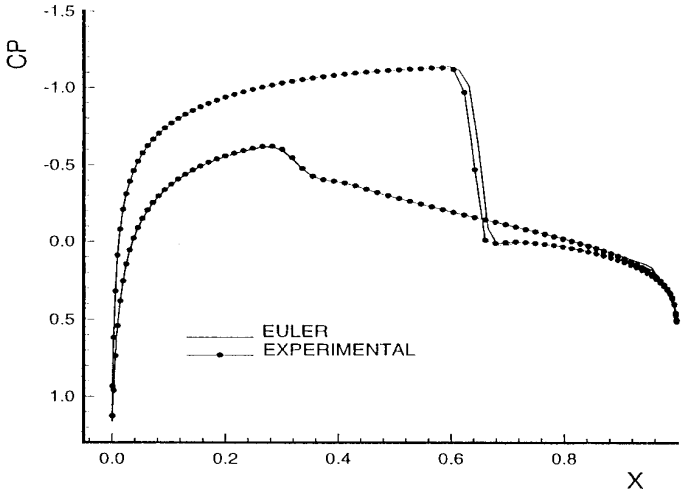


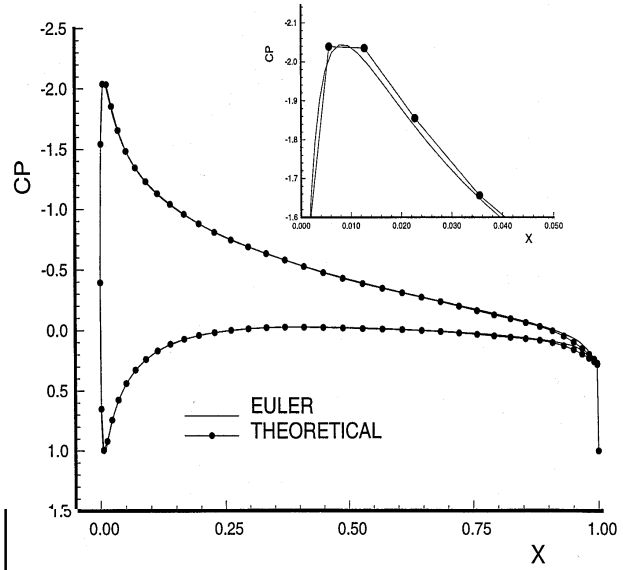
NORMS



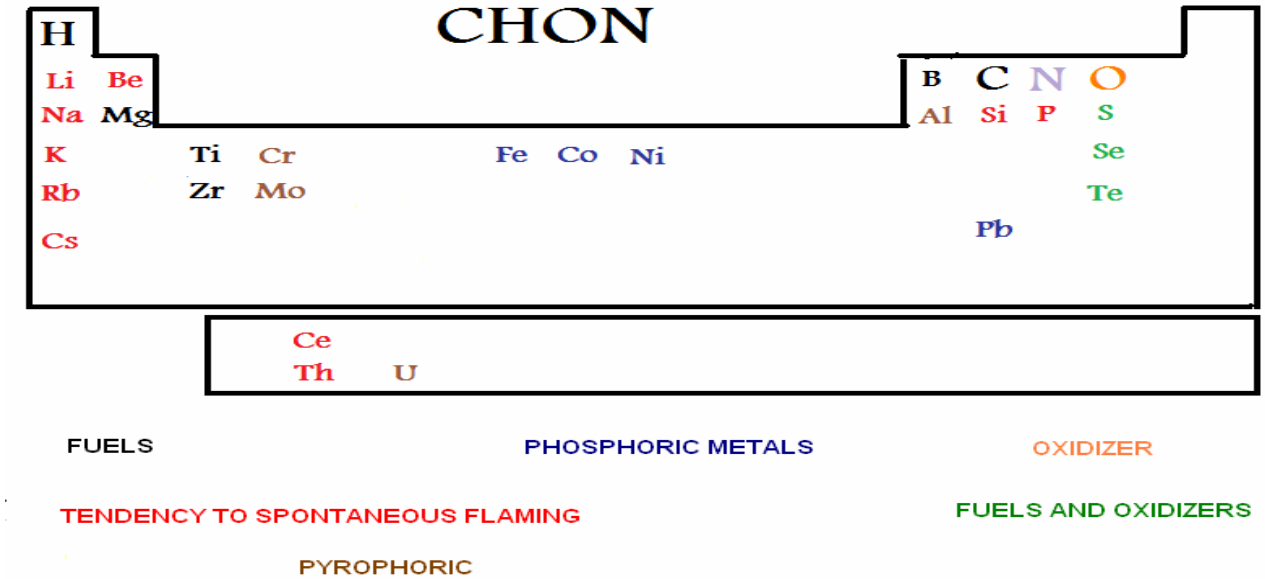
PRECONDITIONING

Confiability

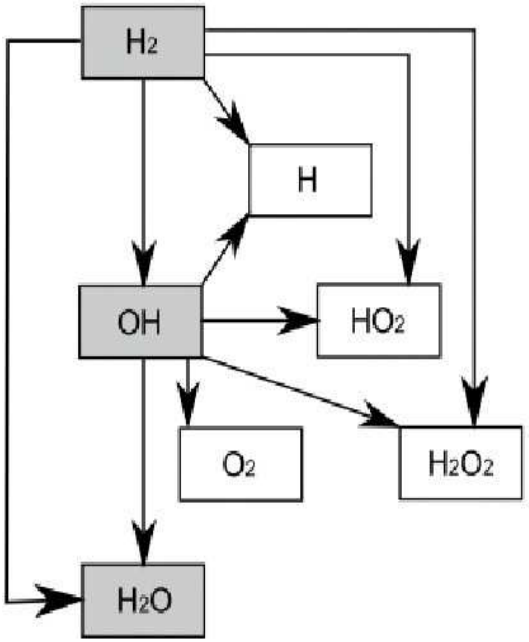


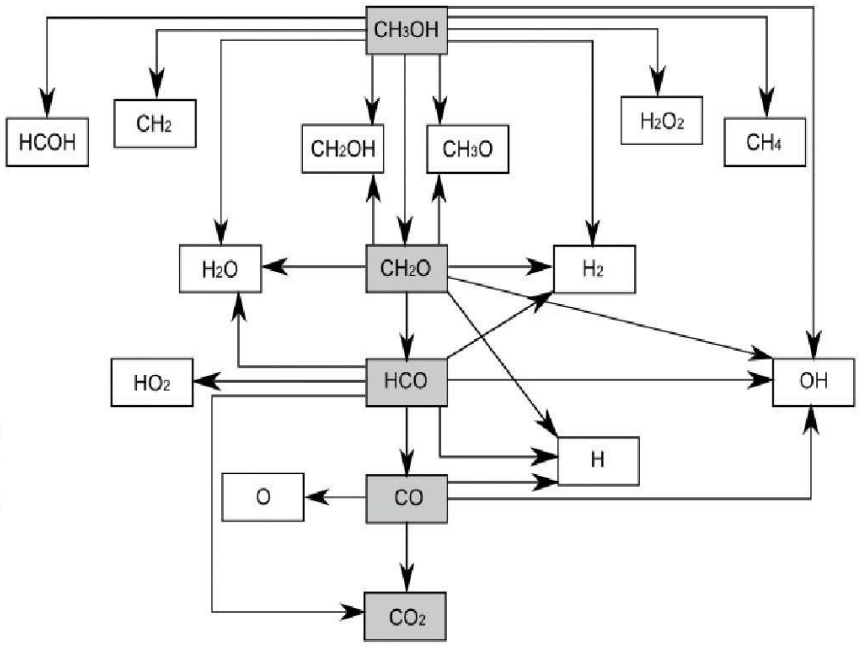


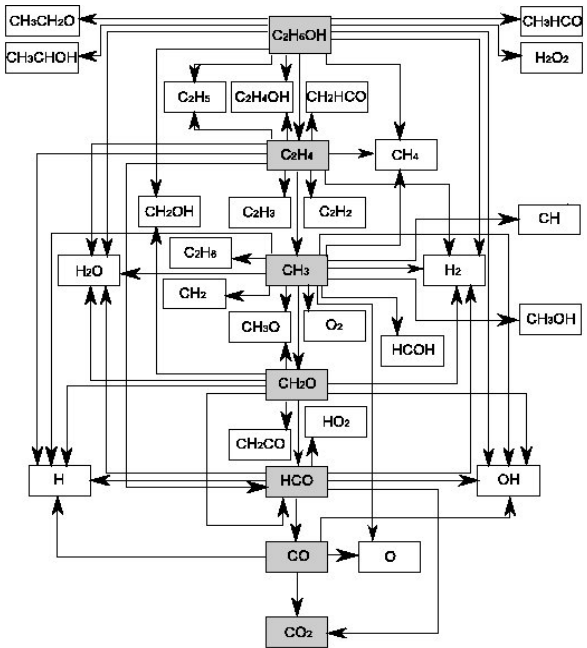
COMBUSTION CHEMISTRY



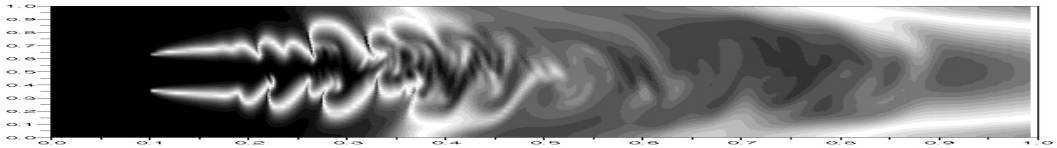
HYDROGEN, METHANOL, ETHANOL (biofuels)

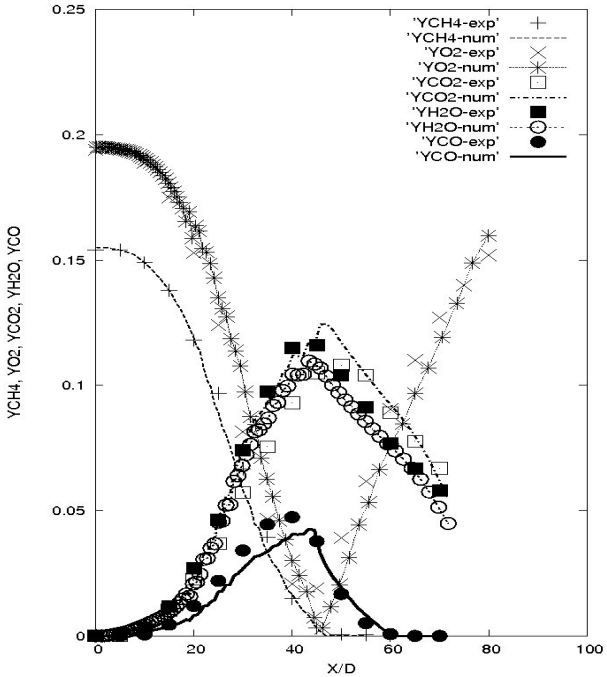


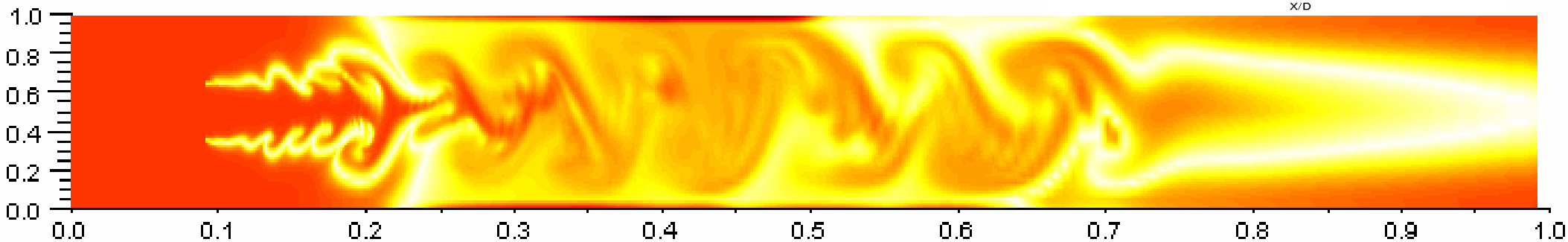


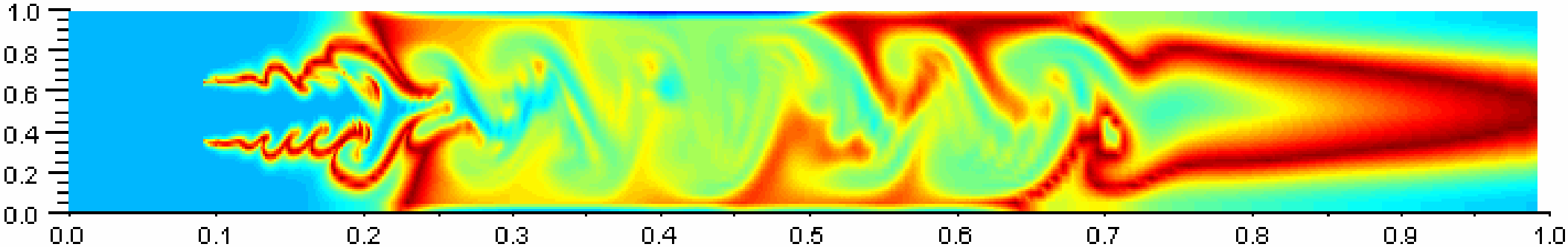


COMBUSTION/FLAMES

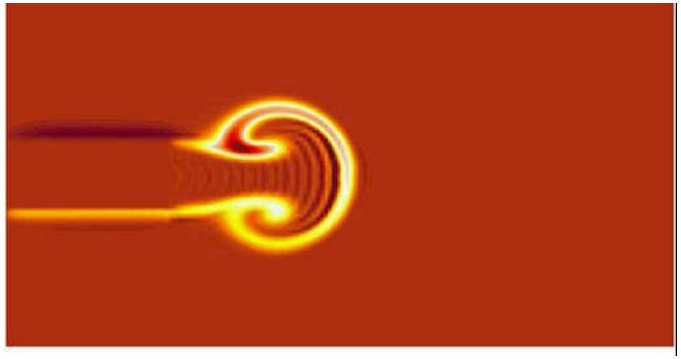


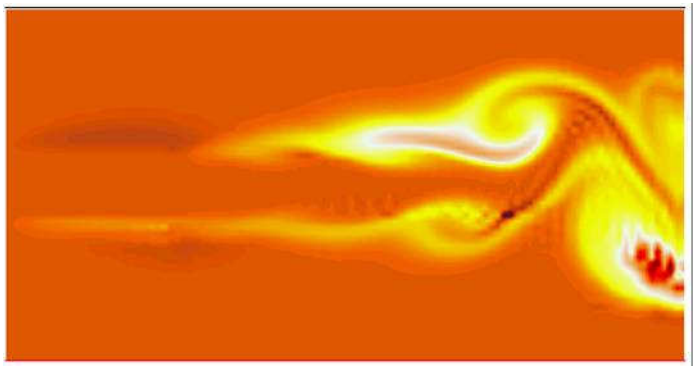


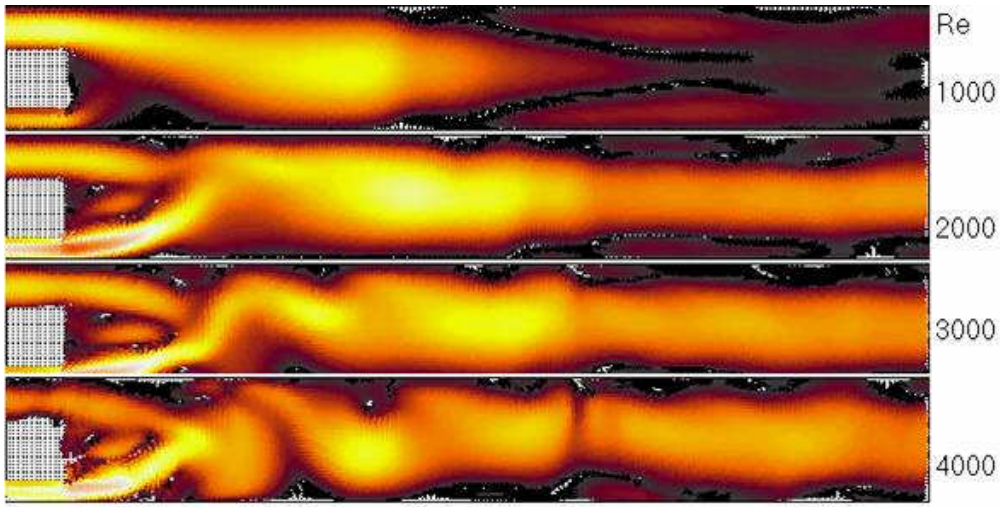


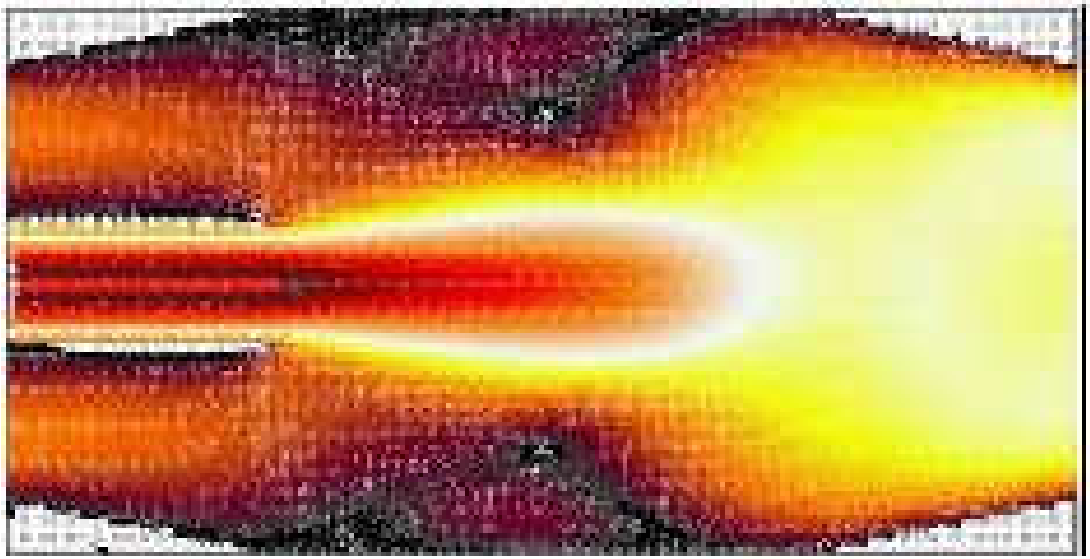


LAMINAR-TURBULENT/COMBUSTION

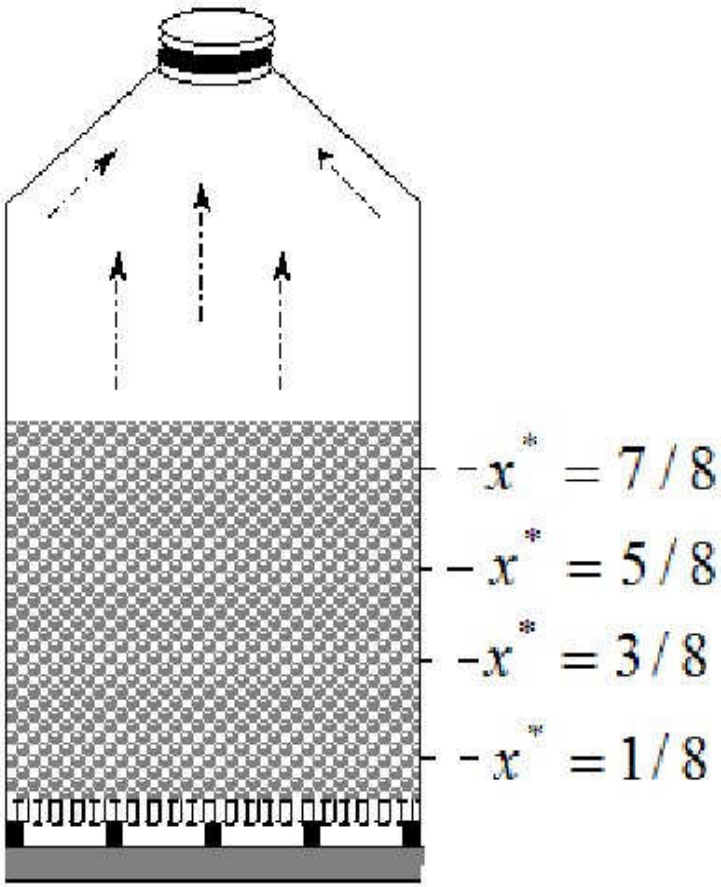


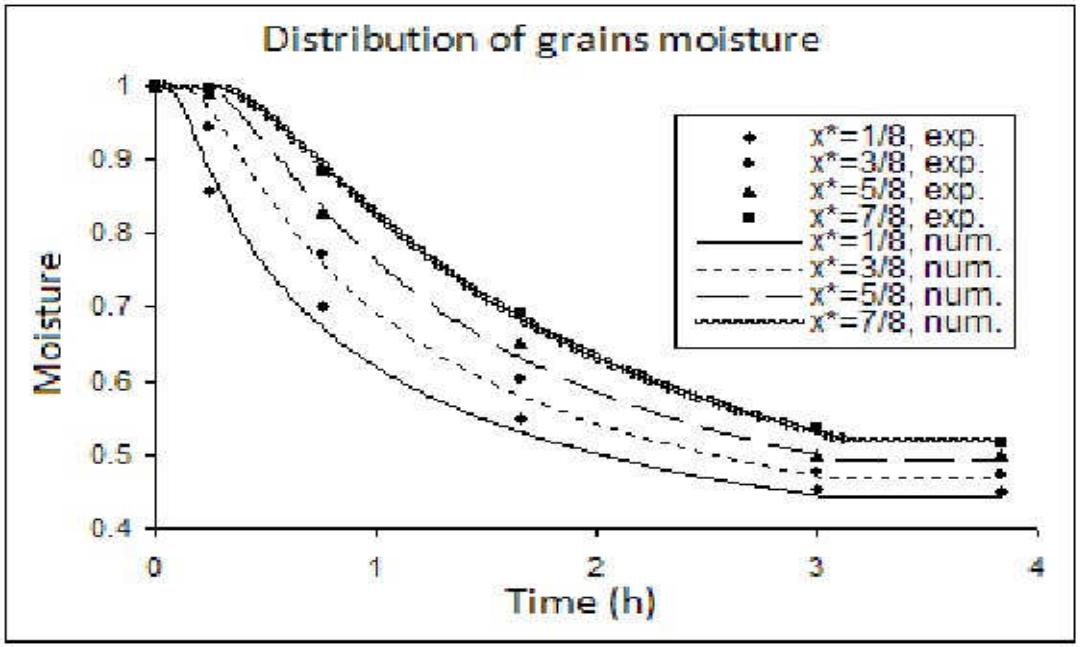


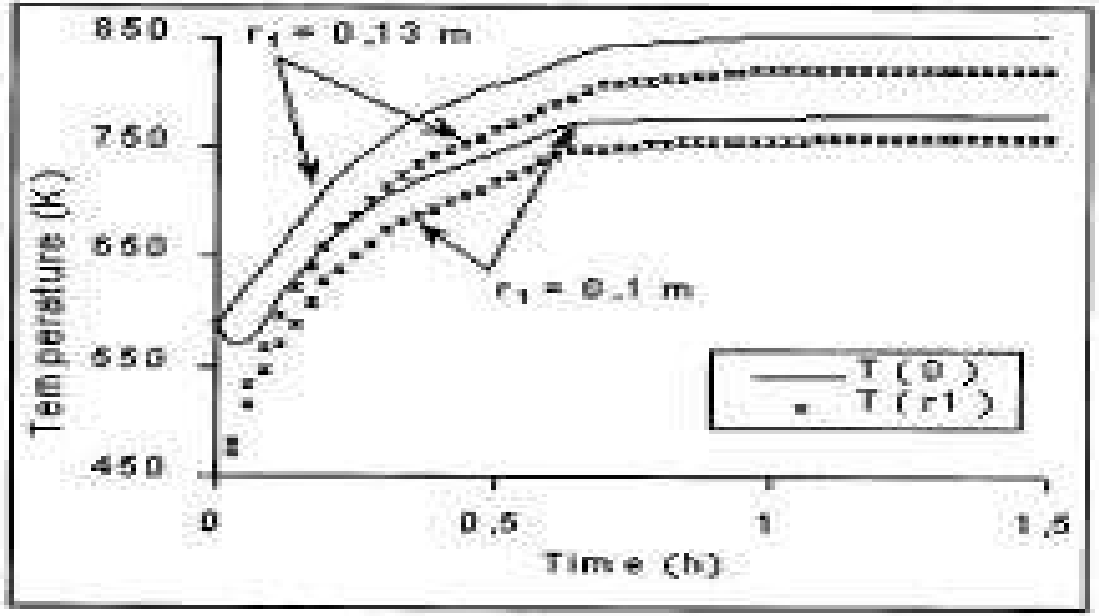




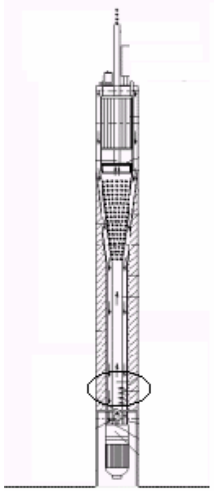
GRANULAR MEDIUM/ DRYING PROCESS HEAT AND MASS TRANSFER

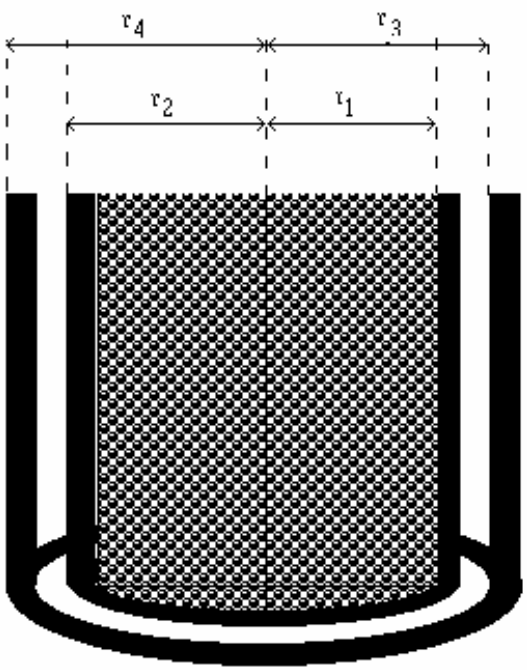


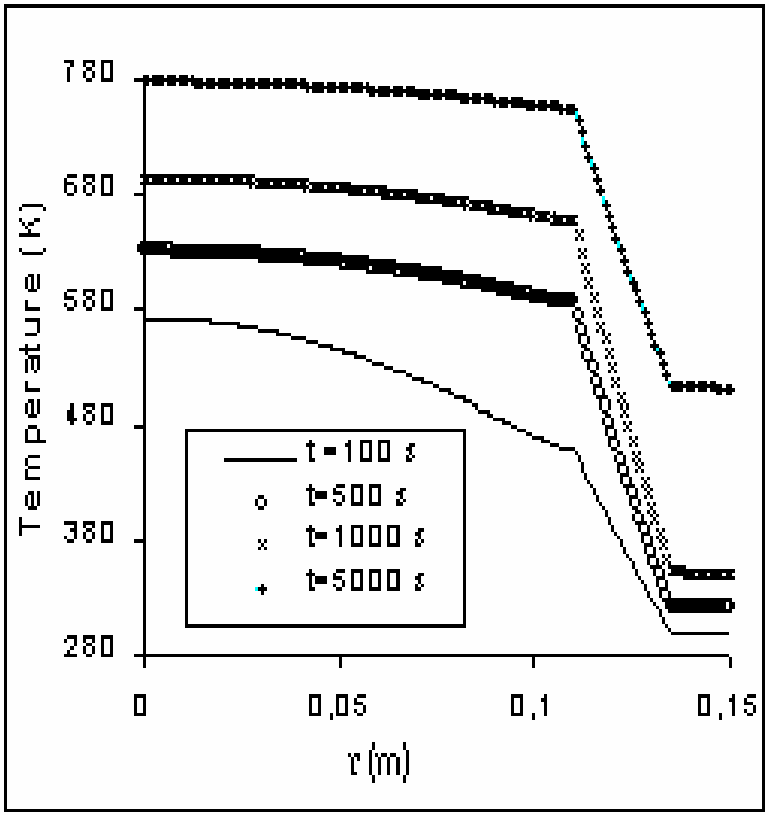


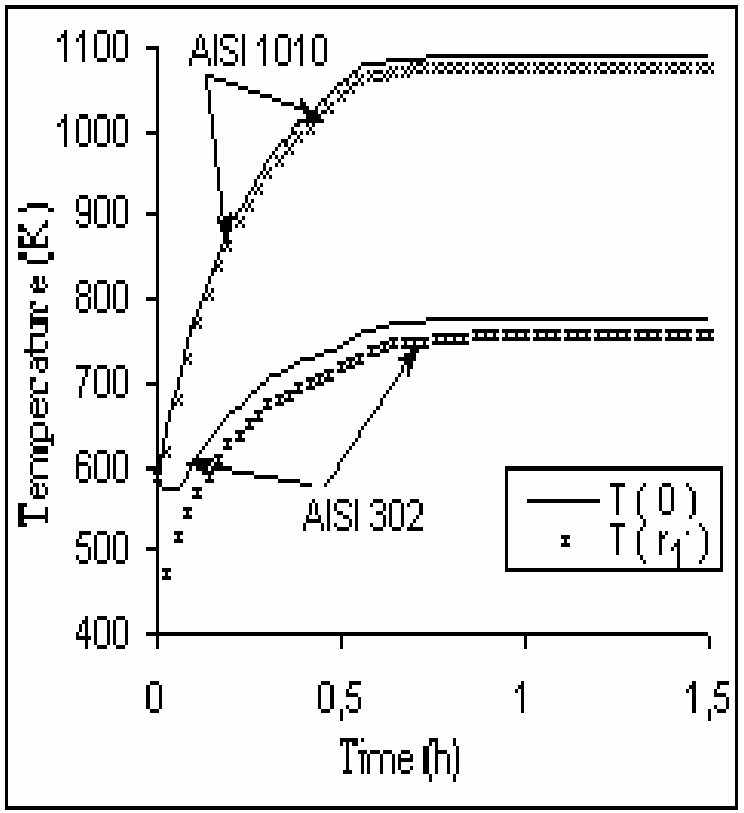


NUCLEAR REACTOR SAFETY/COOLING



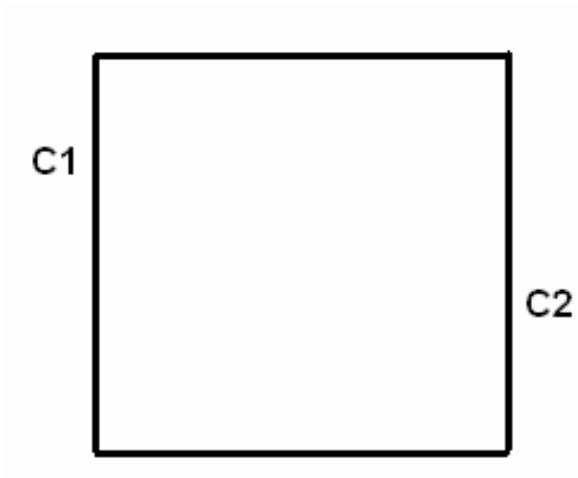


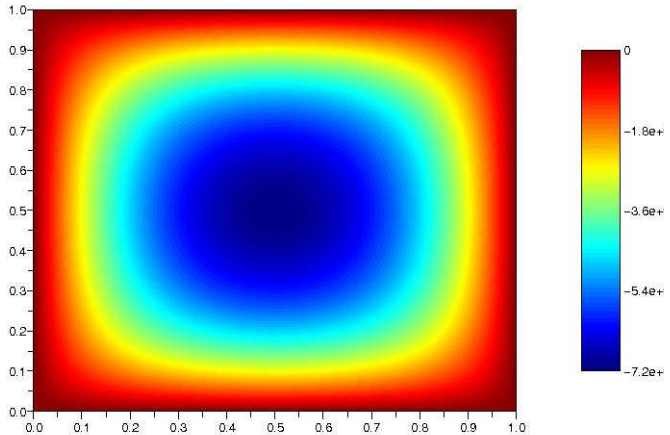


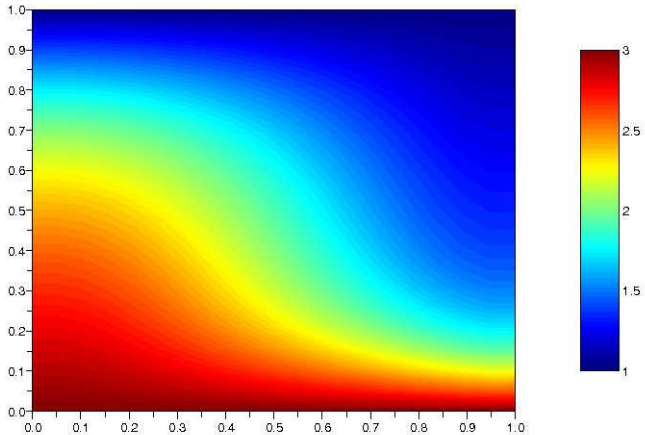


POROUS MEDIA

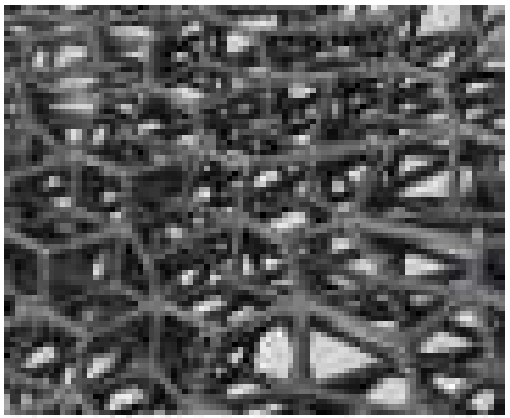
GLOBAL

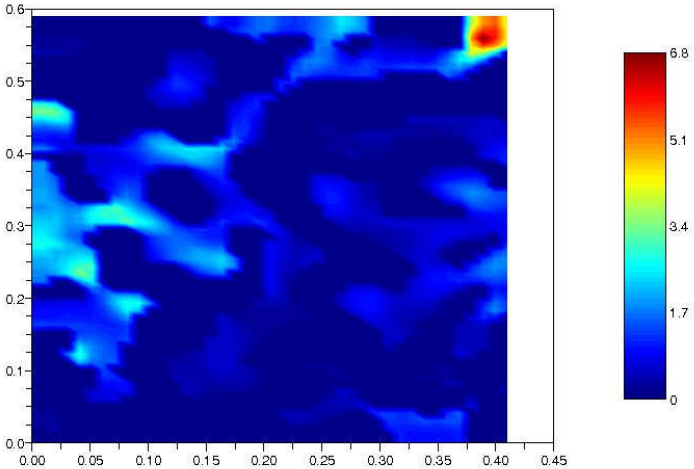


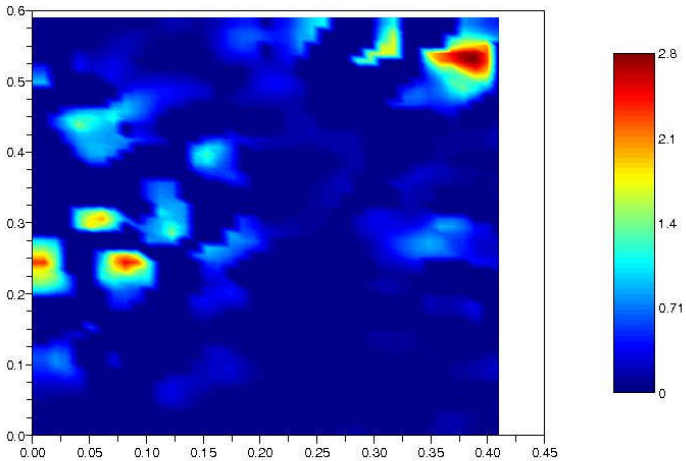




LOCAL

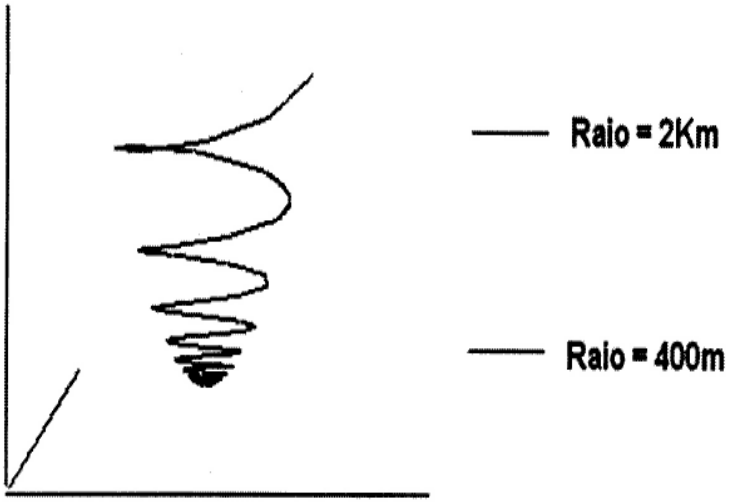
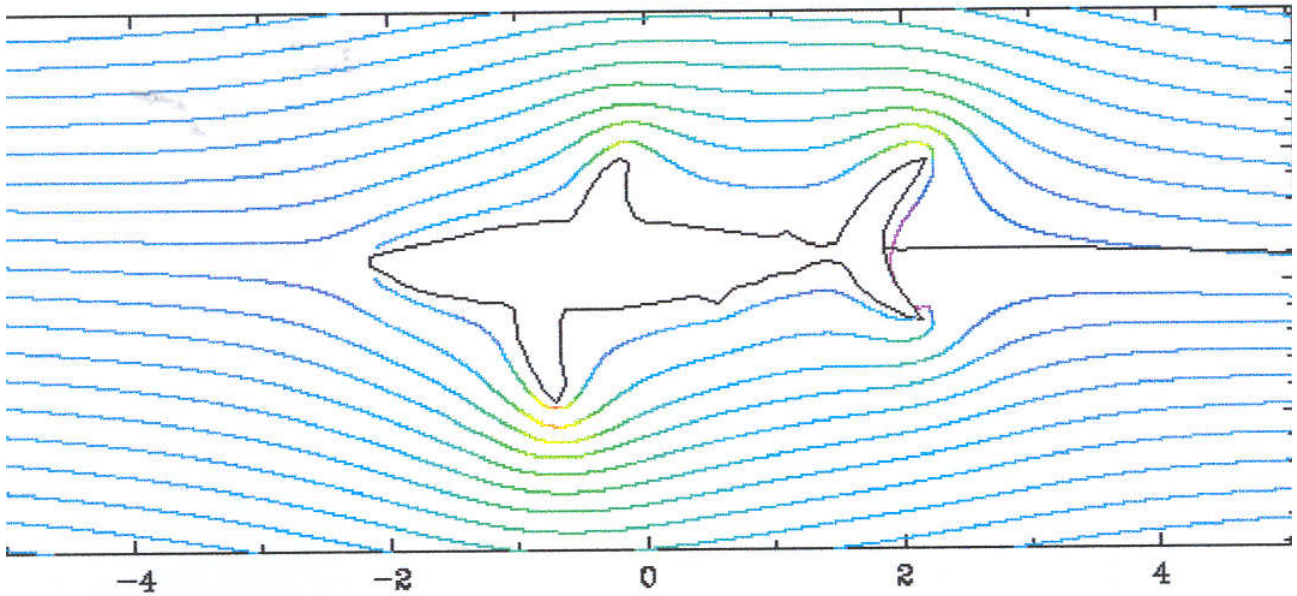






NATURAL FLOWS

TORNADO



SHARK