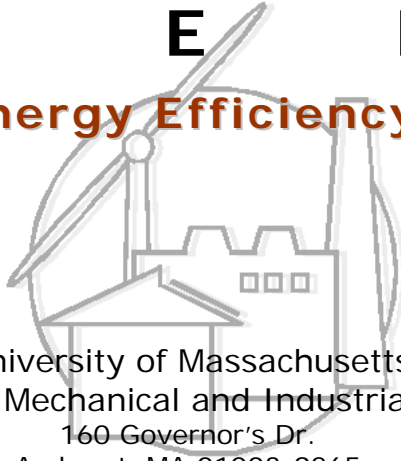


**Center for Energy Efficiency and Renewable
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PROGRESS REPORT

**Simulation of Natural convective Heat Transfer of 3D
Glazing Cavity**

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Problem Description :

A rectangular cavity of dimensions 0.0116m x 0.232m x 0.232m was chosen for simulating 3D natural convective heat transfer at tilted angles. The cavity is shown in the figure below. The rectangular cavity of height(H), length(L) and width(W) has a hot right wall at temperature, T_0 and a cold left wall at temperature, T_1 . The top and bottom walls are adiabatic. The gravitational force is acting downwards. A buoyant flow develops because of thermally induced density gradients. Heat is transferred from the hot wall to the cold wall.

The rectangular cavity is created and meshed using GAMBIT and exported to FLUENT where the boundary conditions are applied and the governing equations are solved. Simulations were carried out for tilt angles 15° and 30° .

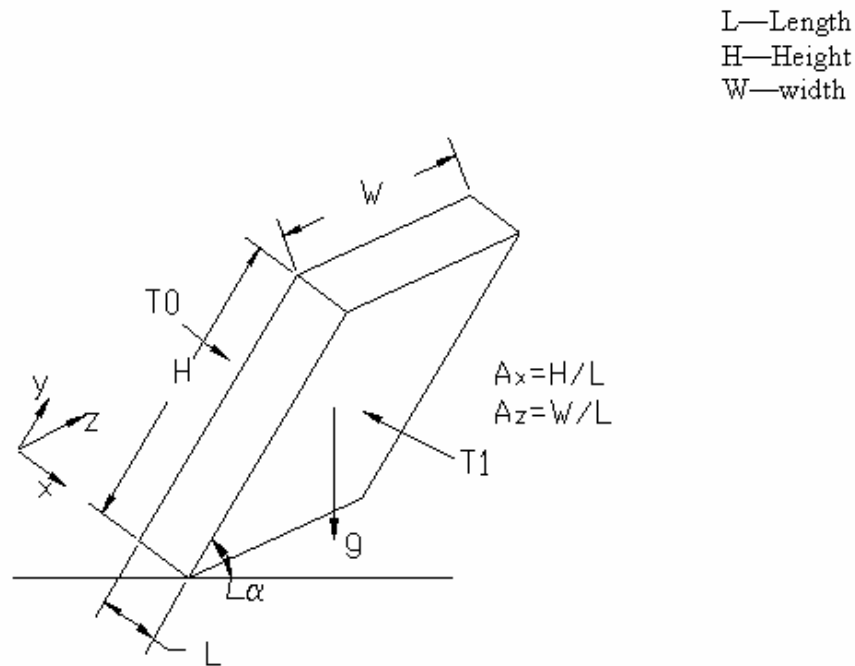


Fig.1 3D rectangular cavity

Detailed results for the glazing cavity

Dimensions:

$$L = 0.0116 \text{ m}$$

$$H = 0.2320 \text{ m}$$

$$W = 0.2320 \text{ m}$$

Boundary Conditions :

surface	Units	B.C.
Cold wall (T_0)	K	259.45
Mean (T_m)	K	270.00
Hot wall (T_1)	K	280.55

Material properties of AIR :

Property	Units	Method	B.C.
Density (ρ)	Kg/m^3	boussinesq	1.30339
Specific heat (c_p)	J/kg-K	constant	1005.7
Thermal Conductivity (k)	W/m-K	constant	0.023866
Viscosity (μ)	Kg/m-s	constant	1.69625E-05
Thermal Expansion Coefficient (β)	1/K	constant	0.0037037
Diffusivity (α)	m^2/s	constant	1.821E-05

The aspect ratio and the calculated Rayleigh number for the above material properties and B.C. is found to be

$$A = 20$$

$$R_a = 9320$$

Meshing and Solution procedure

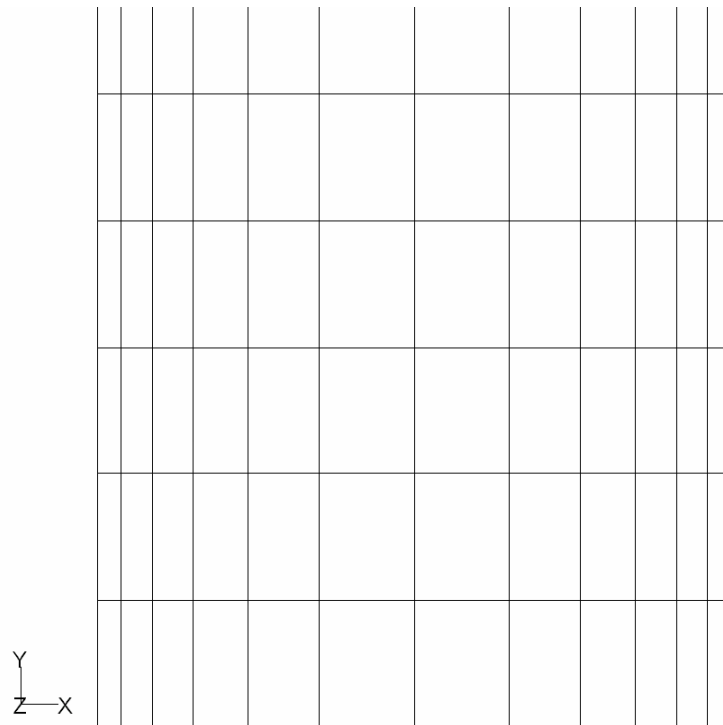
MESH details :

Quadrilateral Mesh

12 grid points along the length

200 grid points along the height

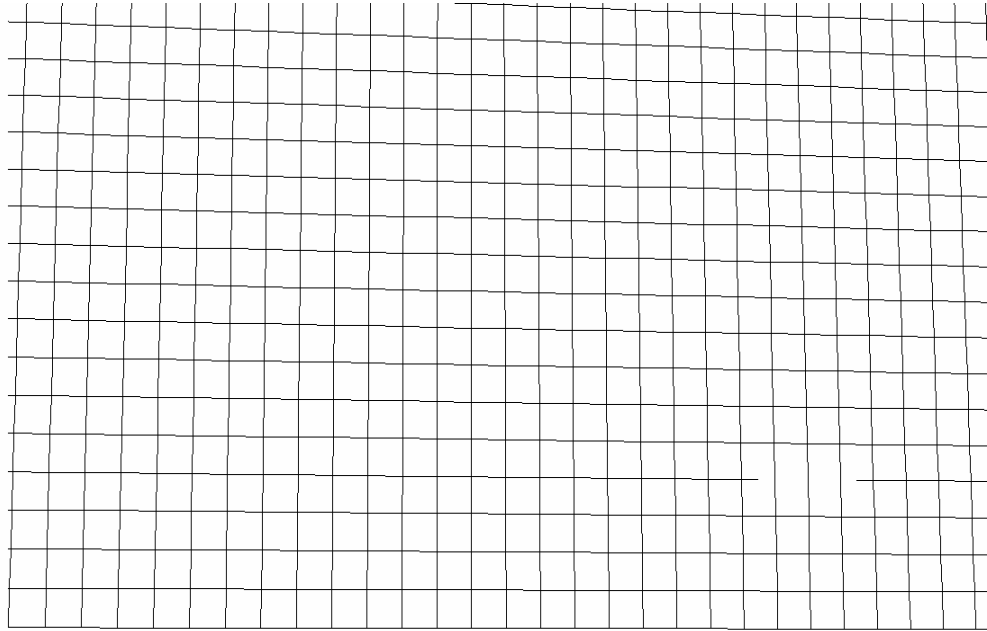
200 grid points along the width



Grid (Time=1.8760e+01)

Feb 17, 2003
FLUENT 6.0 (3d, segregated, lam, unsteady)

Fig. 2. Grid structure along the length(L) direction.



Grid (Time=1.8760e+01) Feb 17, 2003
FLUENT 6.0 (3d, segregated, lam, unsteady)

Fig.3. Grid structure along the height(H) and width(W) directions

Settings in FLUENT :

Solver	Segregated
Formulation	Implicit
Space	3D
Time	Unsteady
Unsteady formulation	2 st order implicit
Velocity formulation	Absolute
Time step (s)	0.14 secs
Viscous	Laminar
Energy	Enabled
Radiation	Off
Gravity	Enabled

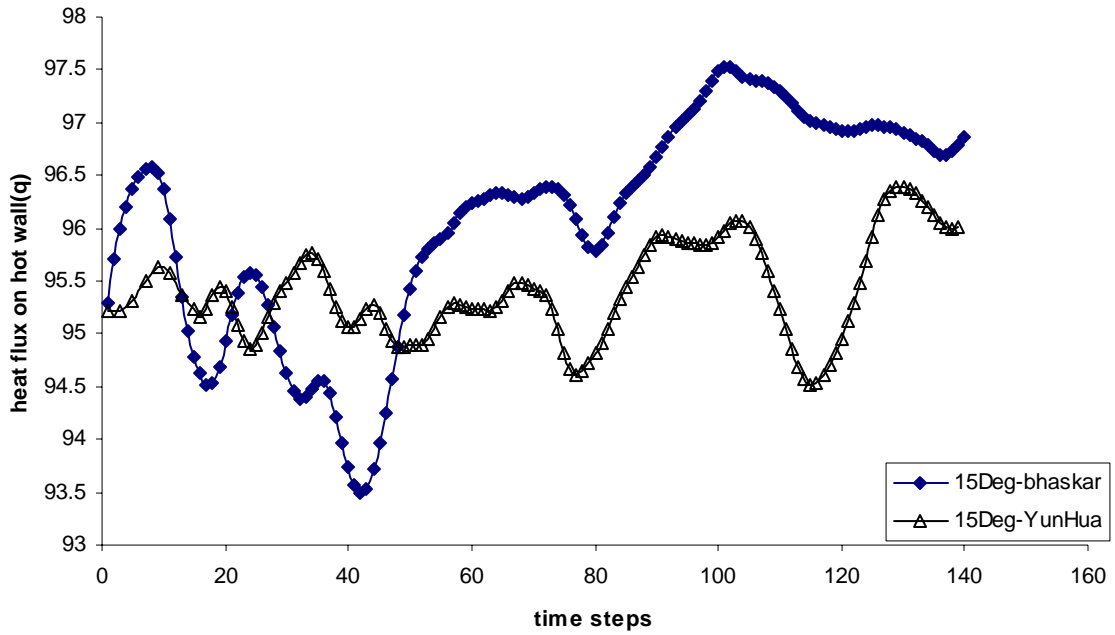
Solution Scheme used in FLUENT :

Variable	Scheme
Pressure	PRESTO!
Pressure-Velocity Coupling	PISO
Momentum	Quick
Energy	Quick

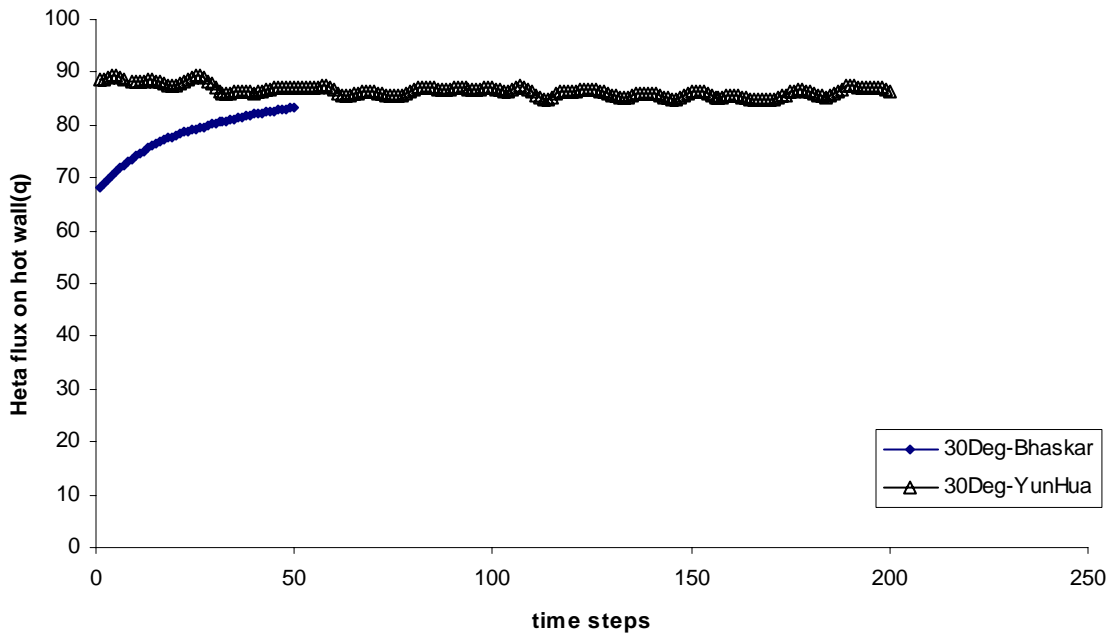
Results:

	15°	30°
Avg. Nu (YunHua)	2.198	1.984
Avg Nu (Bhaskar)	2.213	1.8

Simulation results for 15 Degrees inclination



Simulation results for 30 Degrees inclination



Comments:

The time steps for the heat flux from Yun Hua's simulation are not known and they were obtained by collecting a bunch of data when the heat flux reached a steady trend. So for tilt angle 15° , the heat flux values do not match but we notice that the average nusselt number which is calculated by taking the ratio of the time averaged heat flux and the conductive heat transfer matches closely.

The trend of the graph for tilt angle 30° indicates that further simulations for very large time steps needs to be carried out to achieve a steady trend.

Future Work:

The simulations carried out by Yun Hua provided data for the heat flux on the hot and the cold side of the cavity from which the average nusselt number was calculated. However localized heat transfer data on the hot and cold walls would provide much more information for condensation resistance modeling.

For obtaining local heat transfer data at various positions along the height, surfaces perpendicular to the height need to be created in FLUENT and the heat transfer data has to be collected on these surfaces.

References:

- 1) Elsherbiny, S.M., G.D. Raithby, K.G.T. Hollands. 1982. Heat Transfer by Natural Convection across Vertical and Incline Air Layers. *Transactions of the ASME*. 96/ Vo. 104, Feb. 1982
- 2) Zhao, Y., 1997. Investigation of Heat Transfer Performance in Fenestration System Based on Finite Element Methods. Ph.D. Thesis, Department of Mechanical and Industrial Engineering, University of Massachusetts.
- 3) Yun Hua, 2003. Natural Convective Flow and Heat Transfer in Vertical and Inclined Glazing Cavities. Ph.D. Thesis, Department of Mechanical and Industrial Engineering, University of Massachusetts.