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Heat transfer Comparison Between Fluent and Window5 Results For A Glazing Unit

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In this work, comparison has been done between the heat transfer results from Window and Fluent just for the glazing unit. It was observed that main difference between conduction and convection models occur in the glazing part. Here a double-glazed, low-e coated glazing unit with air as fill gas was taken. Fig1 shows the cross-section view with boundary conditions and materials. Exactly same boundary conditions were applied in the Window5 calculations. Height of the glazing unit was taken as 1m as Window5 does calculations for a standard height of 1m for the glazing. The thickness of each glass is 4.7mm(0.185") while the air cavity is 16.5mm(0.65") wide. So the total thickness of the glazing unit is 25.9mm(1.02").

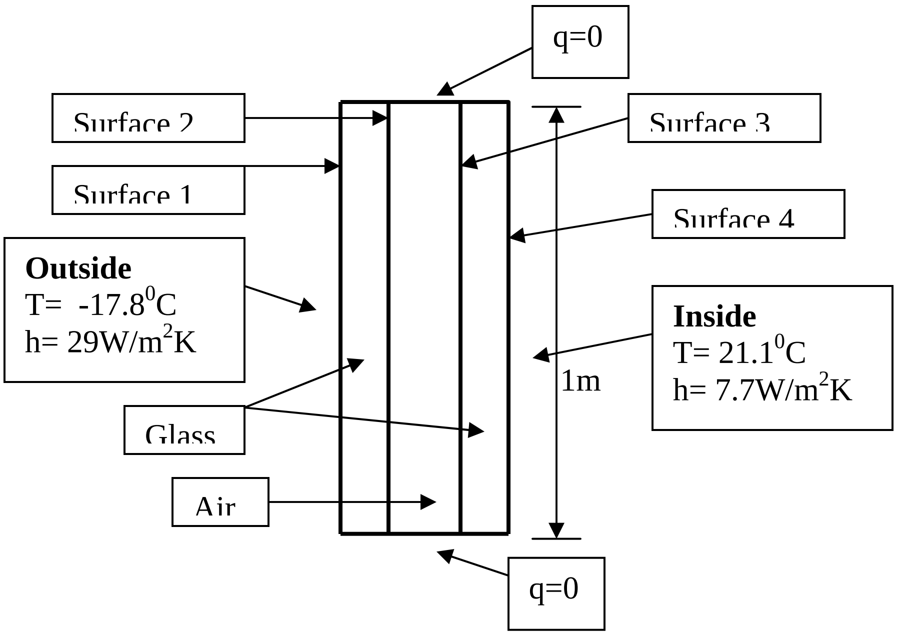

Fig 1: Cross-section view of glazing unit with materials and boundary conditions

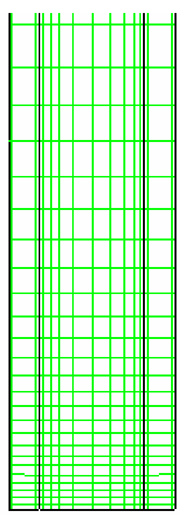

Fig 2: Meshed view of the glazing unit

Results were obtained for conduction and convection model from Fluent. Fig3 shows the temperature distribution on inside and outside surface. Figure 4 shows the heat flux distribution on the hot surface of glazing cavity. Table 1 shows the u-value obtained from various methods.

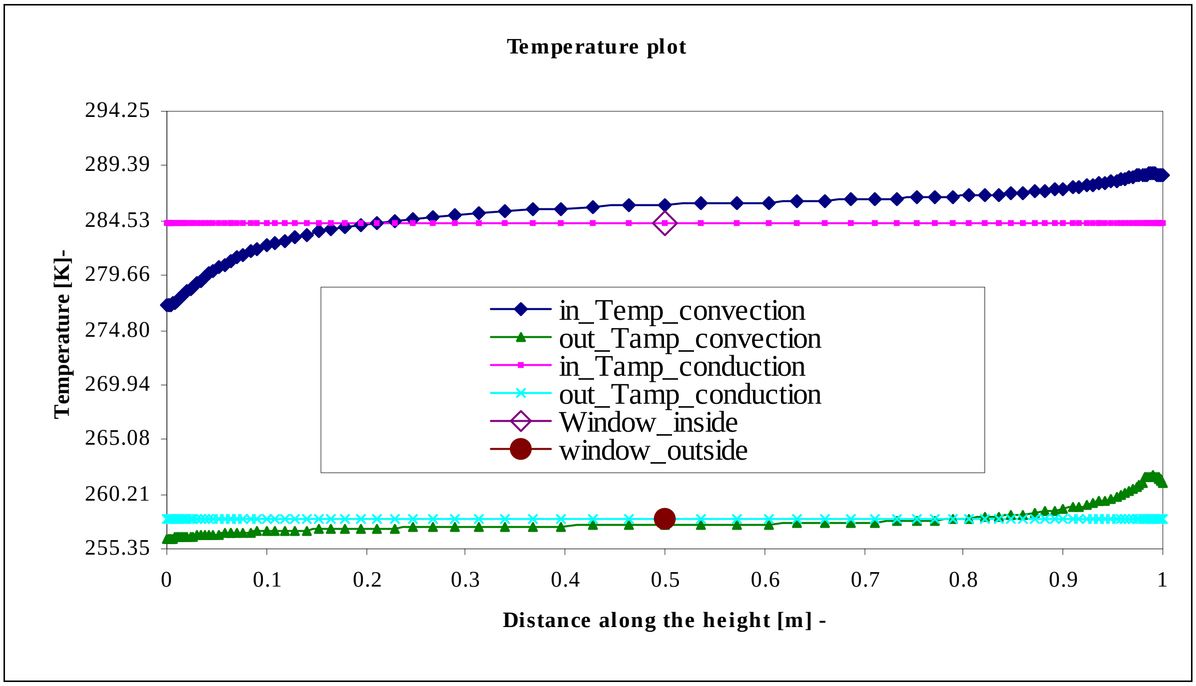

Fig 3: Temperature distribution on inside and outside window surface

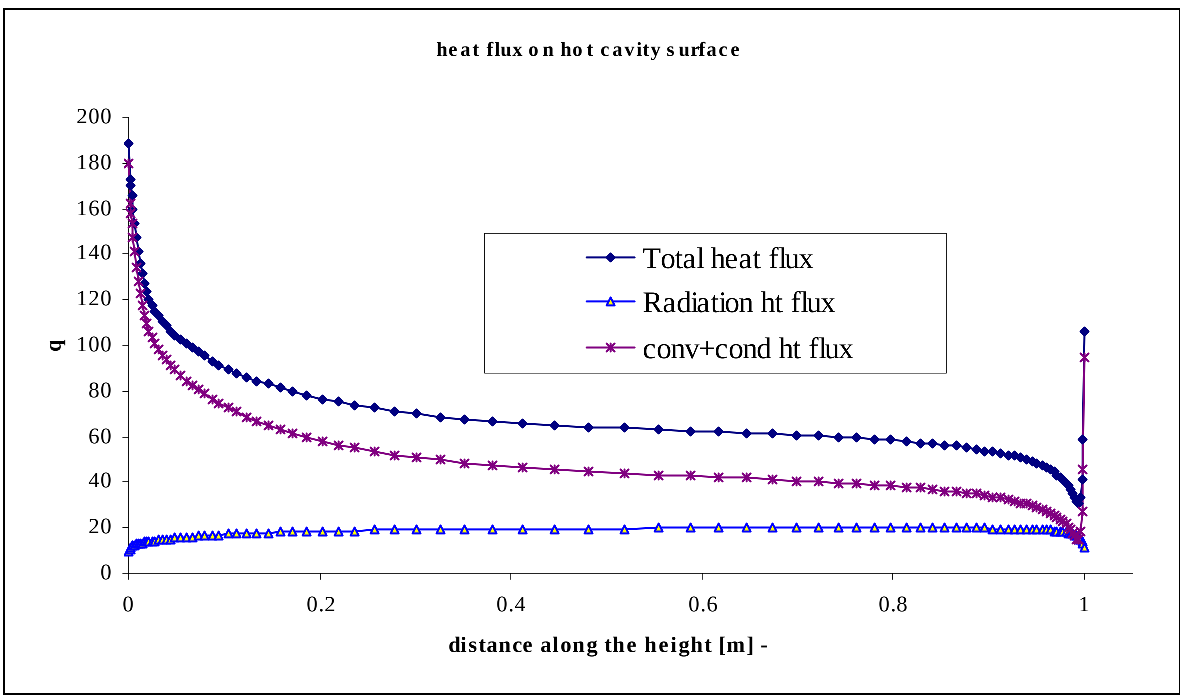

Fig 4: Heat flux distribution on the hot surface of glazing cavity (convection model)

Table 1: U-value for different methods

	Window5	2-d, Fluent-conduction	2-d, Fluent-convection
U-value	1.967	1.965	1.768
% Difference	-	-0.11	-10.11

Table 2 lists the average temperature obtained from different methods on surfaces 1 to 4. For the Fluent models area-weighted average temperature was taken.

Table 2: Average temperature on different surfaces

	Window5	**Conduction model**	% Diff. With window5	**Convection model**	% Diff. With window5
Surface-1	257.95	257.98	-0.012	257.72	0.089
Surface-2	258.35	258.38	-0.012	258.08	0.105
Surface-3	283.95	283.93	0.007	284.96	-0.356
Surface-4	284.35	284.32	0.011	285.32	-0.341

Figure 5 had the plot of local Nu number on the hot surface of glazing cavity. It was calculated using the formula Nu=(*q (y)/(T3 (y)-T2*)*(*d/k*) where q(y) and T3(y) are local heat flux and temperature respectively and d(=16.5mm) is the cavity width and k(=0.0242W/m-K) is the thermal conductivity of air. T2(=258.08K) is the average temperature of surface 2.

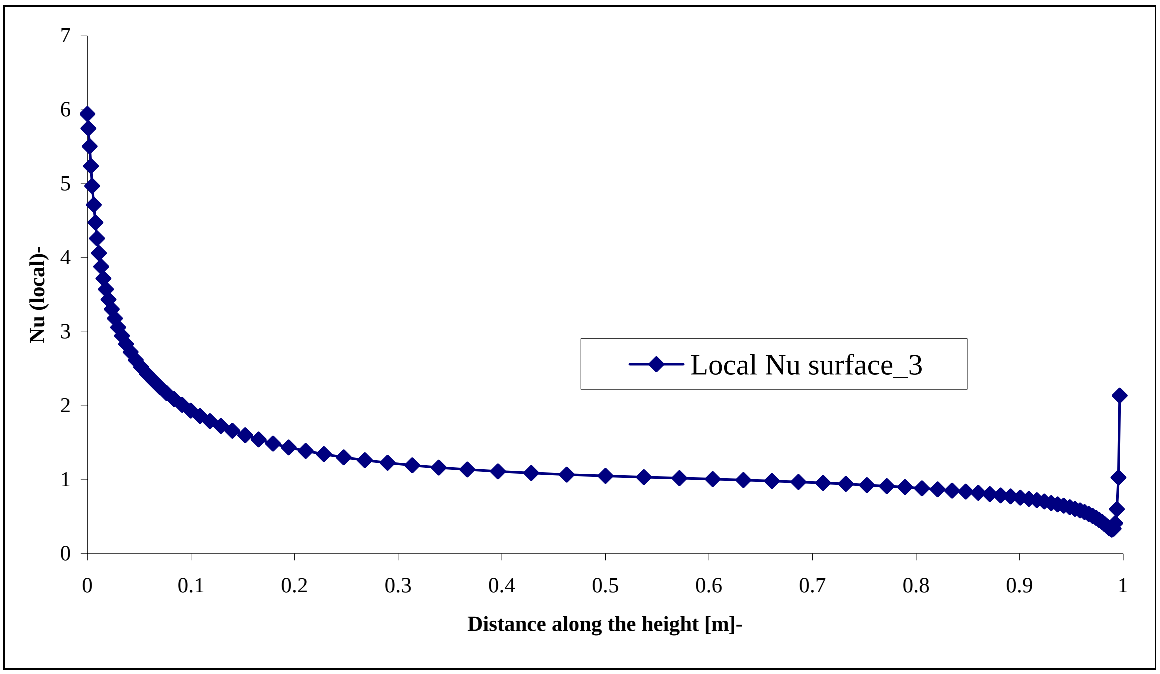

Figure 5: Local Nu number on hot surface of glazing cavity

The Rayleigh number for this glazing cavity was *14,307.4*. The aspect ratio of this cavity is *60.06*. The Nu calculated for this Ra number was as follows. Table3 presents these data and their deviation from ISO15099 calculation.

From ISO 15099: -

$$Nu=(1.470,1.069)_{max} = \mathbf{1.470}$$

From Elshernbiny (Appendix formula): -

$$Nu(A=40) = 1.422$$
$$Nu(A=80) = 1.500 \qquad Nu_{mean}= \mathbf{1.461}$$

From Elsherbiny correlation for vertical cavity: -

$$Nu = (1.469,1.052,1.069)_{max} =\mathbf{1.469}$$

From Fluent data (for hot cavity wall):-

Q_{total}=68.784 W; Q_{rad}=18.888 W; $Q_{conv+cond}$= (Q_{total} -Q_{rad})= 49.896 W

Q_{cond}=K*del_T/d =(0.0242*25.6/0.0165) = 37.547 W (approximation made here)

Nu = $Q_{conv+cond}/Q_{cond}$ =**1.329**

From Local Nu data (fig5):

Average Nu =**1.312**

Table 3: Nu calculated from different methods

	Nu	% Diff. With ISO
ISO 15099	1.470	-
Elsherbiny (appendix)	1.461	-0.612
Elsherbiny correlation	1.469	-0.068
Fluent (average data)	1.329	-9.592
Fluent (local data)	1.302	-11.429

Observation:

Similar to the U-value given by the fluent-convection model, even Nu number is also lower by 10%(approx.) from the Window5 and conduction models. The way we define Nu, it should never be less than 1 but if we see fig5, Nu goes below 1. This is because we are using T2 (average) for calculating the Nu. The average surface temperature predicted by all the models is very close (with in 1%).

References: -

1. Aleksander Fomichev, Laboratory report, 3-D heat transfer PFM window modeling.
2. Fluent and Gambit manual.
3. S.M. Elsherbiny; Heat transfer by natural convection across vertical and inclined air layers.
4. ISO 15099