

Reducing Solar Heat Gain From Inclined Buildings' Roof By Using Radiant Barrier System

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Abstract

Introduction

Energy conservation in buildings is one of the most significant areas of study. In this study, the effect of applying a radiant barrier system (RBS) to the buildings' roof is investigated numerically using COMSOL Multiphysics®. The study reports a simulation model of natural convection in an inclined rectangular channel open ended with different locations of an RBS along the channel thickness (S) shown in Figure (1). The dimensions of the model are (thickness × width × length) 0.05 m × 0.7 m × 1.5 m, respectively. The model is used to adjust the location of the RBS ($A = 0, S/5, 2S/5, 3S/5,$ and $4S/5$) along the thickness of the channel at fixed inclined angle 15 degree and four different uniform heat fluxes (190.5, 285.7, 380.9 and 472.9 W/m²). The objective is to measure the heat flux leaving the lower plate as location of the RBS changes (A). Altering location of RBS reduces the heat gain to the building up to 42 %.

Use of COMSOL Multiphysics®

A non-isothermal flow model is used to offer two-way coupling between fluid flow and heat transfer in the inclined channel. The heat transfer model not only includes conduction and convection but also radiation. To involve radiation in the model, we use the surface-to-surface radiation option that is provided by COMSOL Multiphysics®. First, the depth of the plate is cut to half and we use a symmetric boundary condition to reduce the simulation time. Conduction is used when the upper plate is exposed to a uniform and constant heat flux. The heat then transfers from the lower surface of the upper plate to the air by convection and radiation. Part of the heat reached RBS is reflected to the channel and transmit less energy through the lower plate. The transmitted heat passes through the lower plate by conduction and then discharges to the environment by radiation. The inlet and exit of the channel are exposed to the atmospheric air so we choose "open boundary" option as boundary condition with specified temperature.

Results

Altering the location of the RBS has many affects on the velocity magnitude and temperature of the air, and the heat flux passing through the plates. Figure (2) shows the velocity magnitude when the plates are exposed to 380.9 W/m² and $A = 2S/5$. Figure (3) displays the temperature distribution along the length of the channel at the inner surface of the upper plate. It is noticed that the temperature increases as the location of the RBS moves toward the upper plate. The heat is reflected from the RBS and heats the upper plate significantly as it becomes close to the upper

surface. Figure (4) shows the heat flux enters the building; the location of the RBS affects the amount of heat passing through the roof.

Conclusion

COMSOL Multiphysics® is used to model a complex problem consisting of three modes of heat transfer in addition to fluid flow. This study shows that altering the location of the RBS within the air gap of a channel affects the heat gain to the building.

Reference

W. Puangsombut, J. Hirunlabh, J. Khedari, An Experimental Study of Free Convection in an Inclined Rectangular Channel Using Radiant Barrier, *Experimental Heat Transfer*, 20(2):171-184 (2007)

Figures used in the abstract

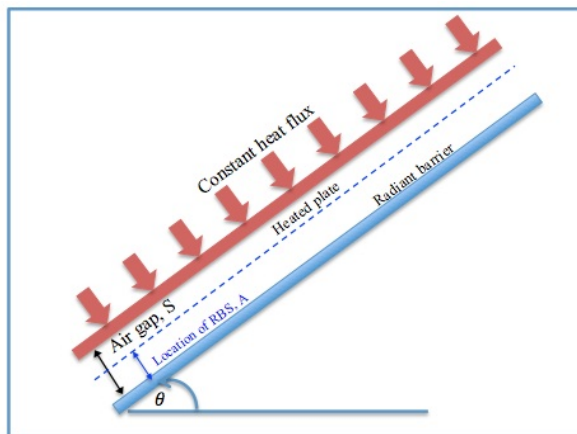


Figure 1: A Schematic of inclined rectangular plate with heated plate and RBS

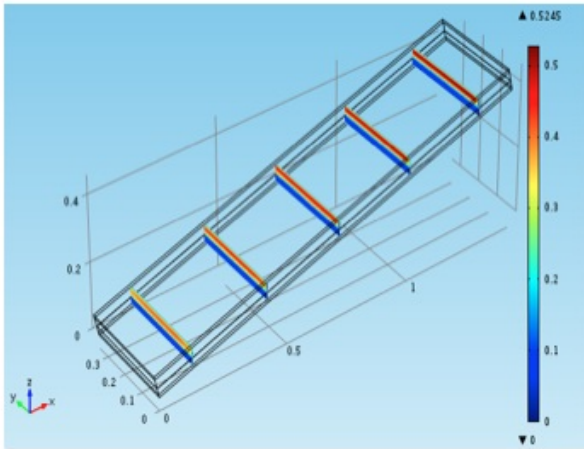


Figure 2: Velocity magnitude for fixed heat flux (380.9 W/m^2), $S= 0.05 \text{ m}$ and $A = 2S/5$

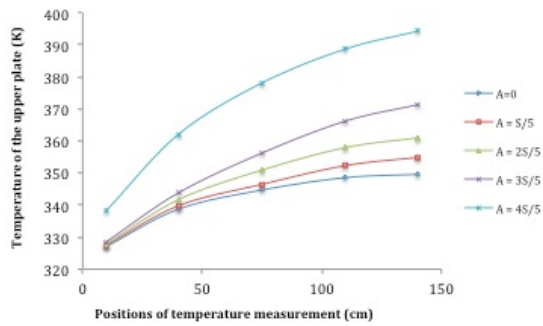


Figure 3: Temperature profile at the lower part of the upper plate along the length of the channel for fixed heat flux (190.5 W/m^2)

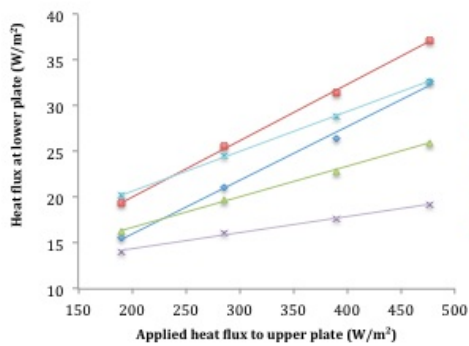


Figure 4: Discharged heat flux at the lower plate for various applied heat flux